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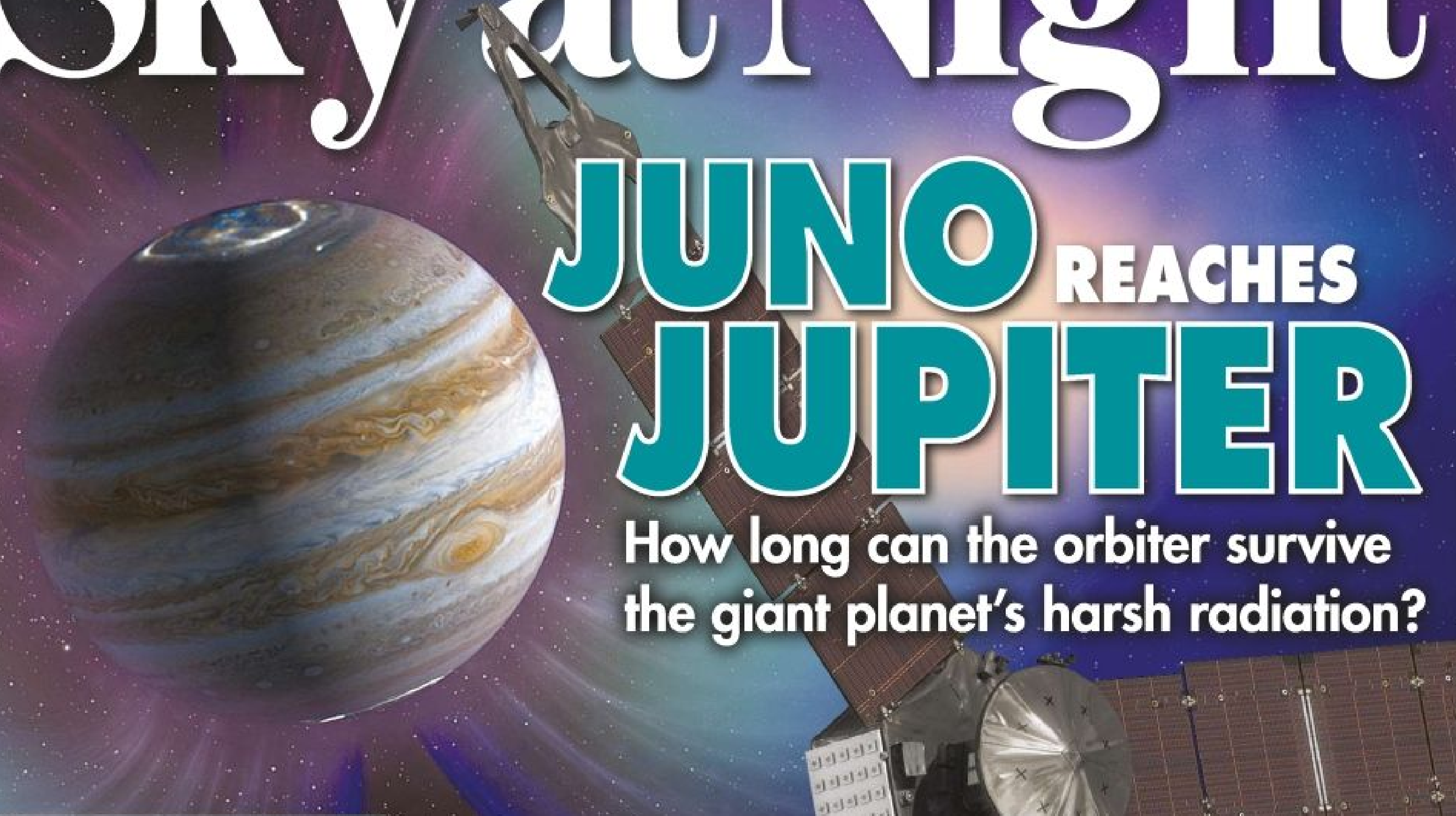

JUNO REACHES JUPITER

How long can the orbiter survive the giant planet's harsh radiation?

STAR TRAIL SECRETS

Take your best photos of the night sky's motion

INTERVIEW

BONUS WEB CONTENT

MISSION TO MOVE AN ASTEROID

We speak to the head of the Asteroid Impact Mission to strike a space rock

- VIRTUAL PLANETARIUM
- SKY AT NIGHT EPISODE
- OBSERVING GUIDES
- AND MUCH MORE...

FAREWELL TO CERES

Dawn mission ends study of the icy dwarf planet

DIGITISING THE SKY

How the LSST observatory will supercharge astronomy

PLANETARY FORECAST

The wildest weather in the Solar System

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REVIEWED IN
ISSUE 112 SEPTEMBER 2014
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This month's contributors include...

MAGGIE ADERIN-POCOCK
SKY AT NIGHT PRESENTER

Maggie explains why we make the effort to observe celestial bodies at multiple wavelengths. *Page 21*

JAMIE CARTER
ASTRO IMAGER

Capturing the march of the stars against the sky as trails is as straightforward as it is rewarding. Jamie gets us started. *Page 38*

MARK PARRISH
DIY EXPERT

In the run up to the Perseids, Mark shows us how to make a multi-DSLR mount to image as much sky at possible. *Page 81*

EMILY WINTERBURN
ASTRONOMY HISTORIAN

Emily tells the tales of 10 space and astronomy pioneers who aren't as well known as they should be. *Page 63*

Welcome

As one space mission ends, another exciting chapter begins

Jupiter has been a target for many amateurs over the past few months since it reached opposition in March, but we're visiting it again in this issue for a different reason. In July NASA's Juno spacecraft will arrive at the gas giant after a five-year voyage through the Solar System, beginning a mission that it's hoped will reveal exciting new details about the planet's interior and enormous atmosphere. On page 32, Will Gater speaks to mission scientists to find out what they're most looking forward to as the probe begins its active phase, and the dangers it faces in one of the most radioactively deadly environments anywhere in the Solar System.

As one space mission begins another one ends, and on page 69 Govert Schilling looks at Dawn, whose observing campaign around dwarf planet Ceres draws to a close at the end of June. As he discovers, there are still many mysteries to uncover at this icy world as scientists begin to dissect the mission data.

Being the biggest asteroid, Ceres is relatively bright and within reach of even a pair of binoculars. Yet there are countless smaller space rocks that can't be seen and our inability here threatens life on this planet. That's why astronomers mark Asteroid Day on 30 June. On page 44 news editor Elizabeth Pearson looks at the projects that will improve our detection rates for these smaller bodies – just as well given close to 20 large asteroids have come between Earth and the Moon this year already. You'll also find an exclusive video interview with the head of ESA's Asteroid Impact Mission in our bonus content online.

Enjoy the issue.

Chris Bramley Editor

PS Next issue goes on sale 21 July

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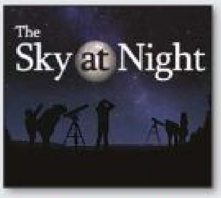

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Find out what *The Sky at Night* team will be exploring in this month's episode on page 19

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Ⓒ Learn how to capture the march of the stars across the night sky in the form of trail images in this astrophotography tutorial.

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Why we can't find all the asteroids that zip past Earth, and why that's a huge problem.

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Names like Newton and Einstein dominate astronomy, but many more played their parts.

69 DAWN'S END
Ⓒ As the spacecraft mission at Ceres comes to an end, we look back at what it has revealed about the largest body in the asteroid belt.

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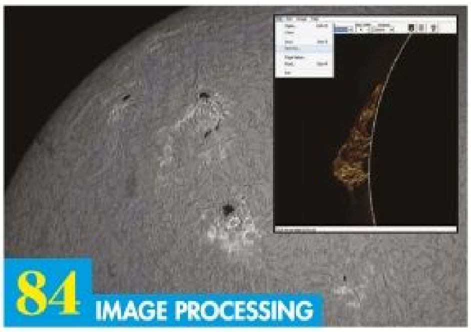
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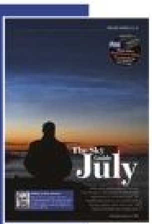

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THE MISSION TO DEFLECT AN ASTEROID

ESA's Asteroid Impact Mission (AIM) will observe a NASA probe crashing into an asteroid at immense speed, helping scientists understand how incoming bodies might be deflected away from Earth. We speak to Ian Carnelli, head of AIM, to find out how this mission could help protect life on our planet.

EVERY MONTH

VIRTUAL PLANETARIUM

With Paul Abel and Pete Lawrence

Take a tour of July's night-sky highlights with Paul and Pete.

HIGHLIGHTS

SKY AT NIGHT EPISODE

The *Sky at Night* team anticipated the Mercury transit in May. Pete Lawrence reveals how to observe a transit safely, while Royal Observatory Greenwich public astronomer Marek Kukula shows how transits enabled early astronomers to learn more about the Solar System.

ASTEROID DAY: HOW TO SAVE THE PLANET

Videos and infographics from ESA reveal the threat of asteroids to life on Earth, and how our planet can be better prepared.

DAWN SPIES THE SURFACE OF CERES

See the surface features of dwarf planet Ceres via NASA animations constructed using data sent back to Earth by the Dawn spacecraft.

AND MUCH MORE…

- ▶ HOTSHOTS GALLERY
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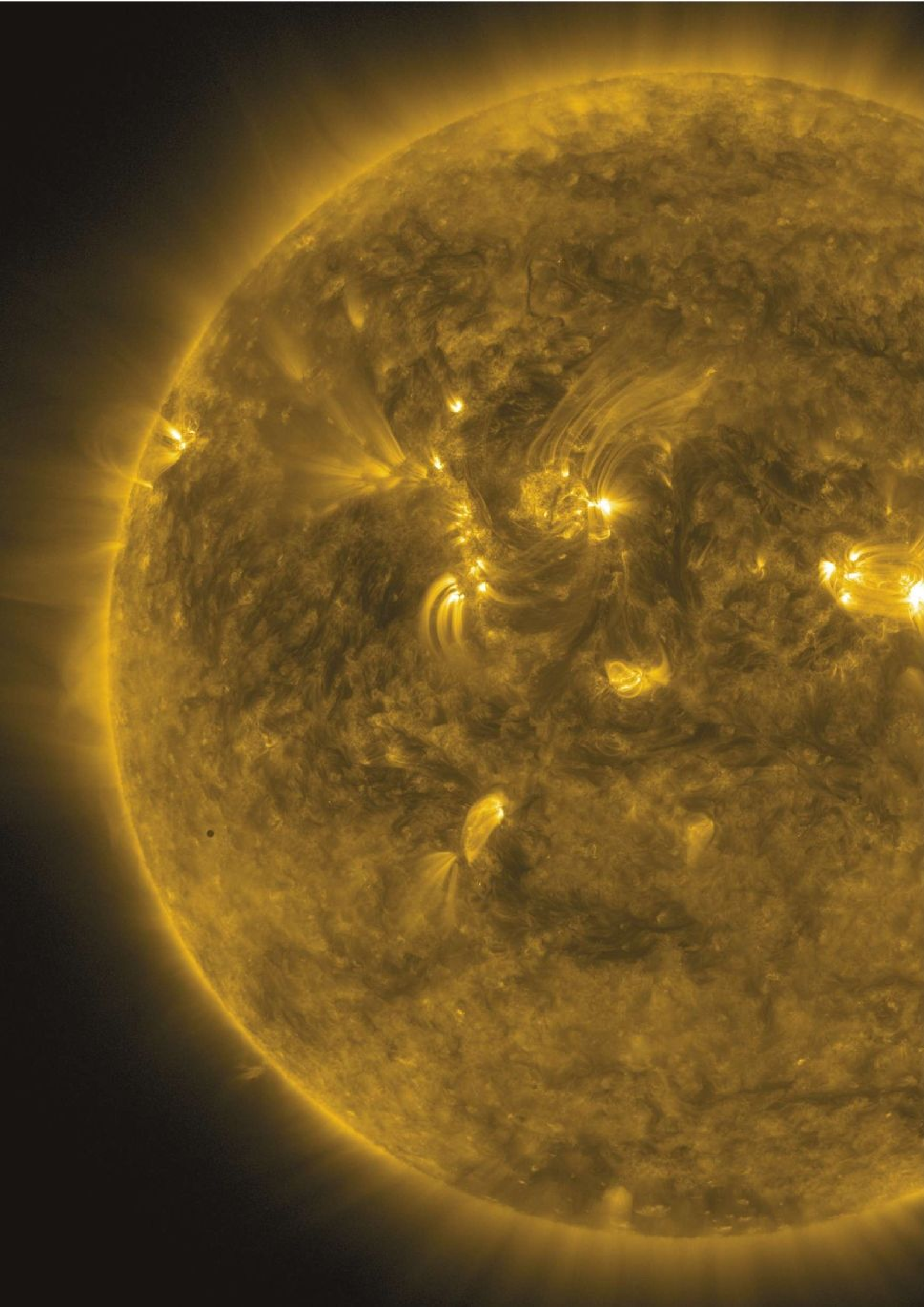


Mercury's passing phase

The transit of the closest planet to the Sun was captured in ultraviolet light, revealing just how small and insignificant Mercury appears against the backdrop of a chaotic solar surface

NASA SOLAR DYNAMICS OBSERVATORY, 9 MAY 2016

On 9 May, Mercury passed in front of the face of the Sun in an event known as transit. This rare occurrence was captured by astronomers and observatories around the world, including NASA's Solar Dynamics Observatory spacecraft orbiting Earth at over 11,000km/h. The image of the transit seen here is the work of SDO's Atmospheric Imaging Assembly, which documents changes in the solar corona by taking images of at least 1.3 solar diameters in multiple wavelengths. This particular image was captured at 11:55 UT at a wavelength of 171 Angströms, which is in the extreme ultraviolet range and shows temperatures of around 600,000 Kelvin. It shows Mercury early on in its transit – the planet appears as a small dot on the left side of the image.

SDO's work provides an unprecedented resource for astronomers to learn more about our host star and its dangers, such as the solar flares and coronal mass ejections that send radiation towards Earth. For the rest of us it shows just how small Mercury appears in comparison to the Sun. If it were Earth transiting instead, it would still only appear a fraction larger than Mercury does, reminding us just how tiny our planet is in the context of the Solar System. Transits also allow planet hunters to detect distant worlds orbiting stars outside our Solar System. Once a far-flung star is spotted, astronomers keep watch to see if there are any dips in brightness, as they could be caused by an undiscovered transiting planet.

YOUR BONUS CONTENT

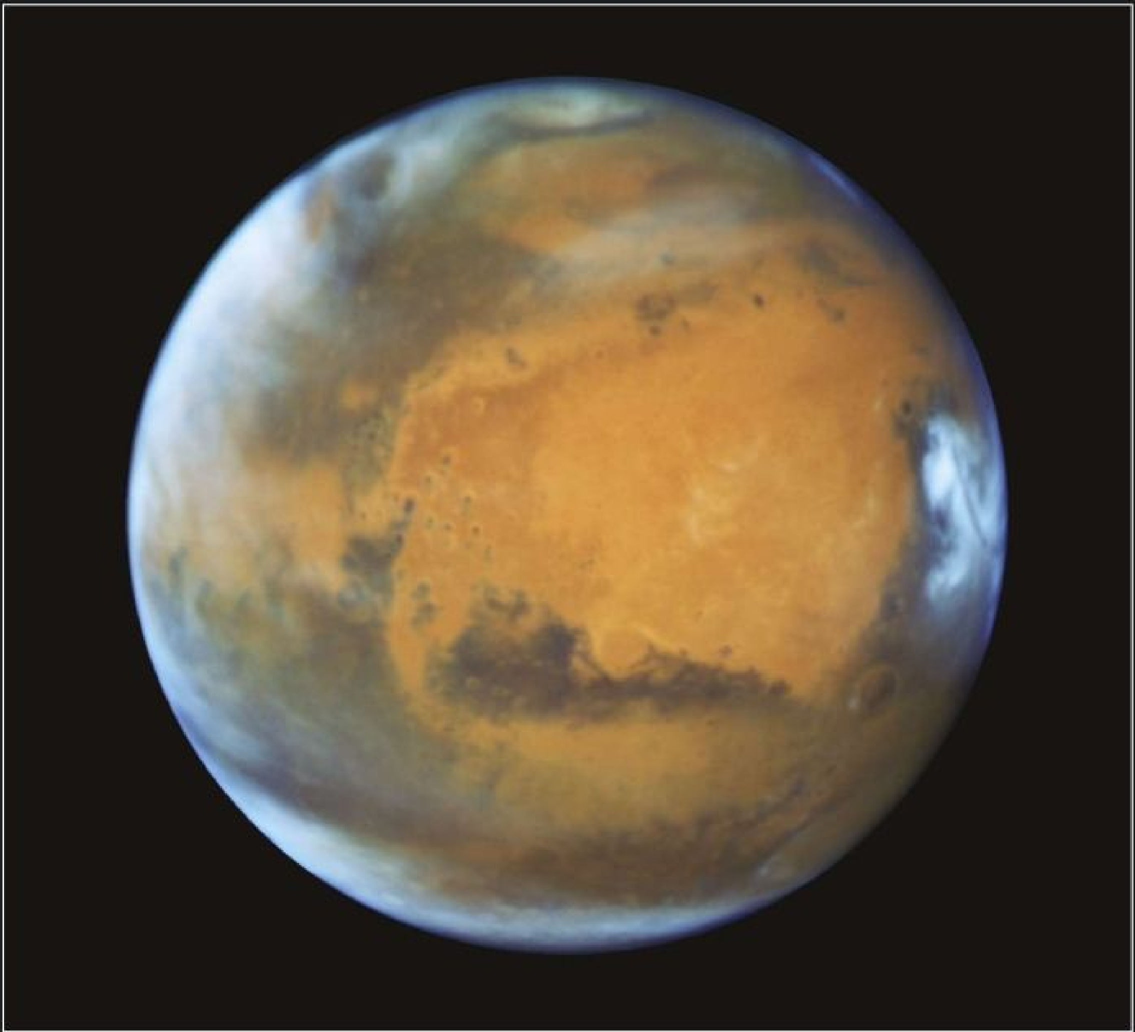
More stunning space images

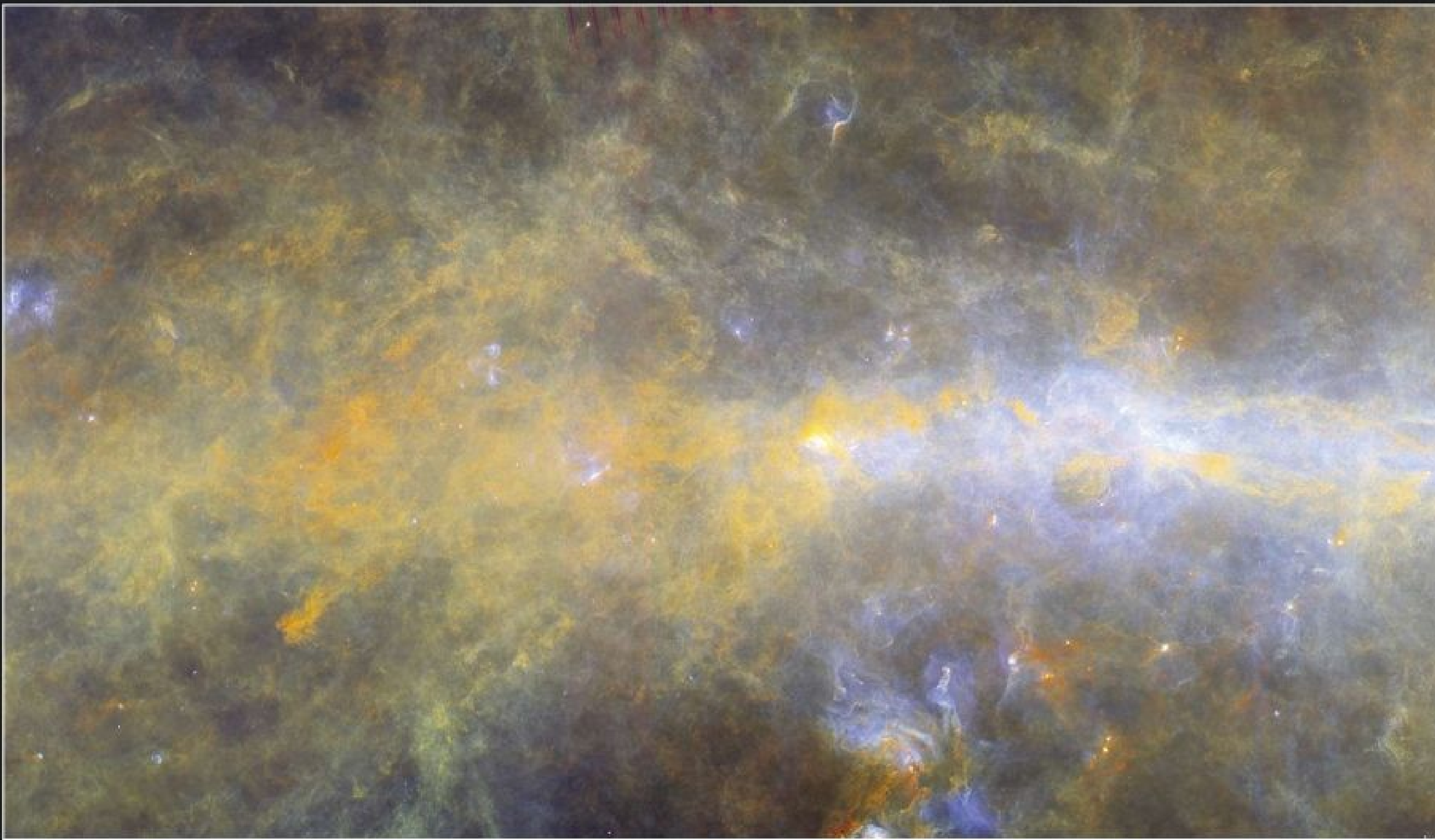
COURTESY OF NASA/SDO AND THE AIA, EVE, AND HMI SCIENCE TEAMS

▶ Mars at opposition

HUBBLE SPACE TELESCOPE, 12 MAY 2016

While images captured by rovers on the Martian surface usually reveal the Red Planet to be a barren, lifeless landscape, this Hubble image paints it as a dynamic, seasonal planet with polar caps (top and bottom) and a cloudy atmosphere. The picture was taken just before Mars reached opposition on 22 May, when it and the Sun aligned either side of Earth.





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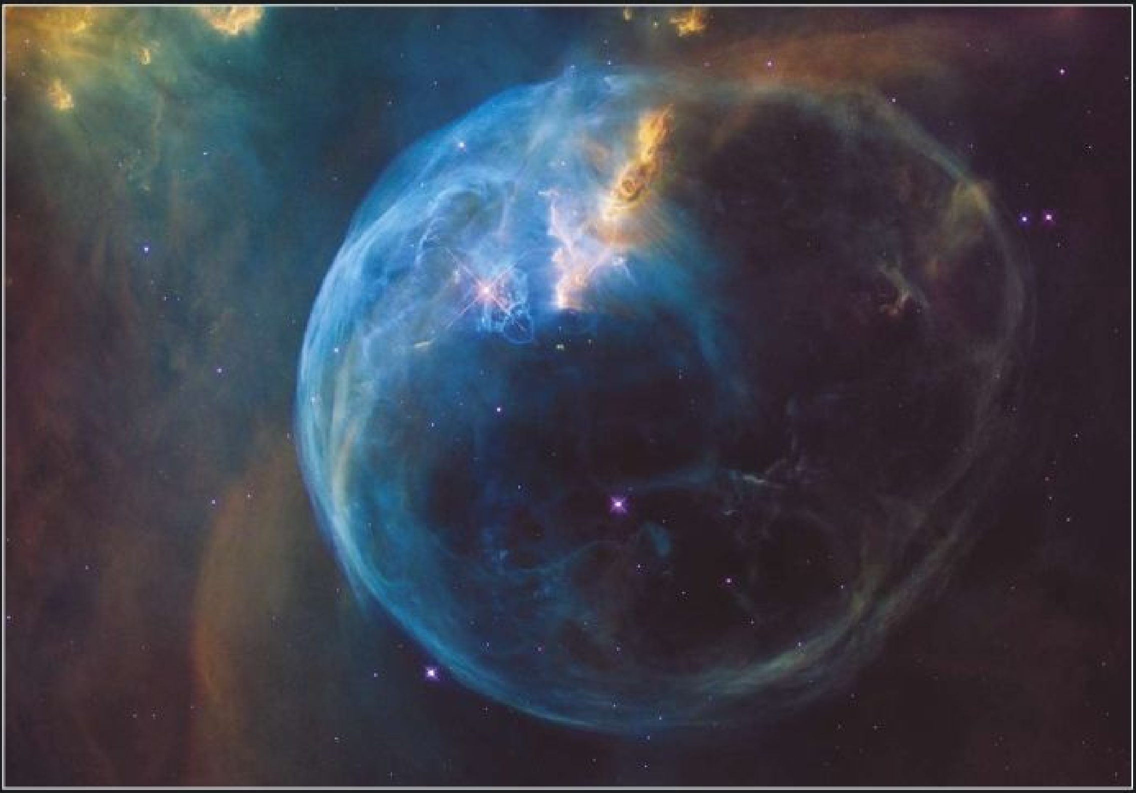


◀ Hubble bubble

HUBBLE SPACE TELESCOPE, 21 APRIL 2016

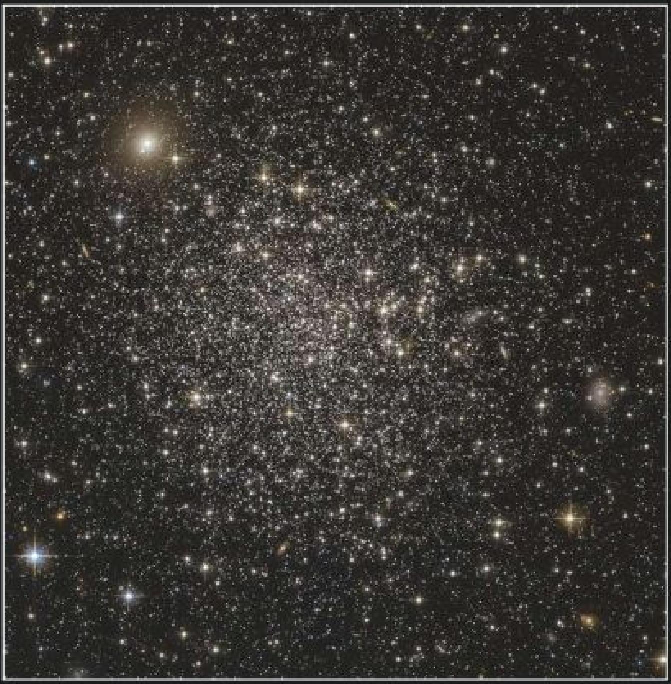
Earlier Hubble images of the Bubble Nebula only reveal parts of its expansive nature, but this composite allows us to view it as a whole for the first time.

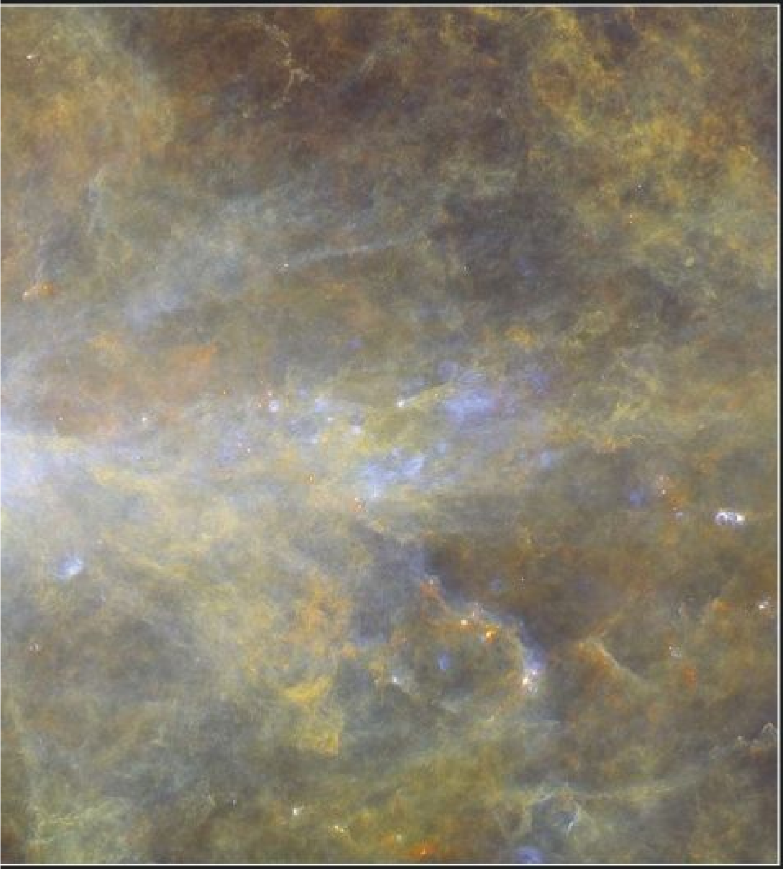
The round shell that gives the nebula its name is the result of a stellar wind blowing from the star SAO 20575, just to the left of centre. Its stellar wind blows out the surrounding cosmic material to form a majestic spherical shape.

Sparkling in the cloud ▶

THE HUBBLE SPACE TELESCOPE, 25 APRIL 2016

NGC 339 is a massive glistening star cluster that is part of the Small Magellanic Cloud, a dwarf galaxy that is just one of a collection of galaxies known as the Local Group. Astronomers estimate that it is about 6.5 billion years old.





◀ Herschel maps the galactic centre

HERSCHEL SPACE OBSERVATORY, 22 APRIL 2016

The Herschel Infrared Galactic Plane Survey (Hi-GAL) was the largest of all observing missions undertaken by ESA's Herschel Space Observatory, which ceased operations in 2013. The study consisted over 900 hours of observations covering two per cent of the sky in order to map the entire disc of the Milky Way. The Hi-GAL team spent two years processing the data and just recently released a portfolio of maps of our Galaxy, of which this one shows the galactic centre. In the middle of the image, clouds of gas and dust form along a giant ring, which is over 600 lightyears wide and includes the central supermassive black hole.

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Bulletin

The latest astronomy and space news written by **Elizabeth Pearson**

PLUS CUTTING EDGE

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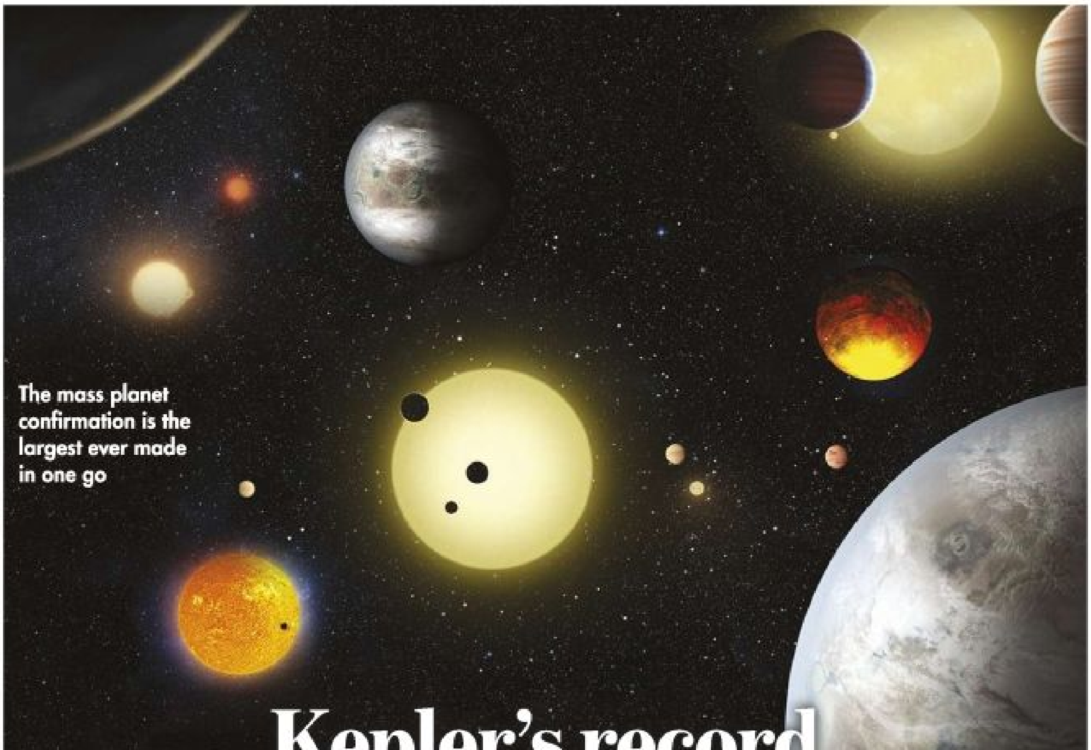
Our experts examine the hottest new astronomy research papers



The mass planet confirmation is the largest ever made in one go

NASA/W. STENZEL

Kepler's record PLANET HAUL

A new planet-verifying method reaps huge rewards

A MASSIVE HAUL of 1,284 new exoplanets has been verified, the largest number ever confirmed at once. The confirmation of the alien worlds, some of which may be habitable, was made by applying a novel technique to Kepler detections.

Previously, hours of painstaking ground-based follow-up observations were necessary to verify potential exoplanets. But this time researchers used a software called Vespa for their confirmations.

"Vespa is a culmination of a change in attitude about how we deal with these large data surveys," says Timothy Morton from Princeton University, who led the research. "The problem that Kepler created is that we now have thousands of new planet candidates. Astronomers knew we couldn't follow up all these in the traditional way, but there was nothing to replace it."

To make the confirmation, Vespa compares the real Kepler data to simulations to determine the likelihood of the candidate being real. The method can detect all kinds of transiting exoplanets but it excelled at picking out rocky worlds, finding 550 in this latest release. Nine of those were within the habitable zone – the region around the star where water can pool as a liquid. En masse verification will become even more important for the next planet-finding telescope, the Transiting Exoplanet Survey Satellite (TESS), due to launch in 2017.

"The data rate from TESS will be even higher than that of Kepler, making it even more important to have trustworthy algorithms to calculate the odds that a given signal really arises from a planet as opposed to an 'imposter'," says Joshua Winn, deputy science director of TESS.

▸ See Comment, right

COMMENT

by Chris Lintott

Though most planet candidates will turn out to be a planet, not all will, and with telescope time a scarce resource we may never find out which are real and which are not.

The big worry is a background eclipsing binary. Imagine two stars in orbit around each other, hidden behind a foreground star. Normally we see light from all three, but when the two background stars eclipse each other we see a small dip, which observers focused on the foreground might mistake for a planet.

This new code tests these possibilities, distinguishing planets from stars and represents worthy work, but it will shortly, I hope, be obsolete. Both NASA and ESA are planning missions to look for planets around nearby, brighter stars. Follow-up for these will be much less challenging, requiring smaller scopes. A disappointment to those who like building complicated statistical models, but a relief to the rest of us.

CHRIS LINTOTT co-presents *The Sky at Night*

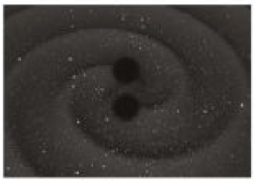
NEWS IN BRIEF

CHEMISTRY SIGNALS LIFE ON EUROPA

The ocean of Jupiter's icy moon Europa may have the chemical energy balance necessary for life. Research has shown that the ratio of oxygen to hydrogen is similar to that of Earth, around 10 to one. Their abundance relative to each other indicates how much energy is available for the chemical processes of life. "The cycling of oxygen and hydrogen in Europa's ocean will be a major driver for Europa's ocean chemistry and any life there, just as it is on Earth," says JPL's Steve Vance, who led the study.

ARE BLACK HOLES DARK MATTER?

Simulations have shown that primordial black holes created a fraction of a second after the Big Bang could explain the effects of dark matter. In September 2015, LIGO detected the first gravitational waves, believed to originate from black holes of the right mass to be primordial – 29 and 36 solar masses respectively. As LIGO continues to detect these objects, researchers will be able to determine their density and test the theory that these are the elusive dark matter.



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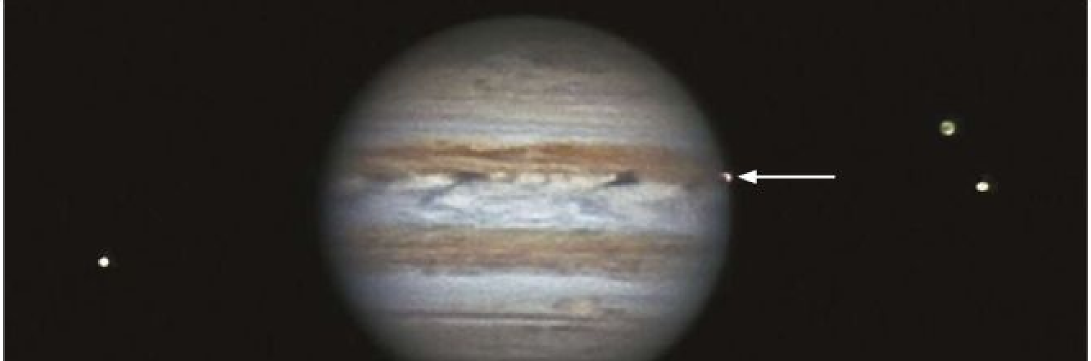


The 17 March fireball, captured by John McKeon and Gerrit Kernbauer

JUPITER BLASTED BY FIREBALLS

Amateur observations have determined the rate of the impacts

THE KING OF the Solar System planets endures an average of 6.5 impacts per year that are large enough to be seen from Earth. As no professional telescopes regularly observe Jupiter, it was a different group that made the measurement – amateur astronomers. The reports of hundreds of astronomers over six years was compiled together at a workshop run by Europlanet 2020.

Meteors regularly impact Jupiter's thick atmosphere, creating spectacular fireballs, which amateurs sometime serendipitously catch during observations. Since June 2010 four such impacts have been observed by non-professionals. The most recent of these occurred on 17 March 2016, later coming to the attention of amateur John McKeon.

"I remembered I had been filming Jupiter around the same time," says McKeon. "When I checked back through my videos, I found the impact in the second to last video I had taken. This secondary observation helped to confirm the impact event."

But not all astronomers are leaving it to luck. Around the world, several amateur groups regularly observe the planet specifically looking for fireballs. One group, coordinated by Marc Delcroix, has generated around 53,000 videos – more than 56 days of footage – but they have yet to find a single meteor strike. "Dramatic impacts with Jupiter can be captured with standard amateur equipment and analysed with easy-to-use software," he says. "But to get a good estimate of how often these events occur, we need observers around the world who are willing to collaborate to create a programme of more-or-less continuous monitoring of Jupiter. It takes time and commitment – observations of no impacts are just as important as detecting a fireball."

Knowing how long the planet remained impact free is vital to calculating the average rate of meteor strikes on Jupiter. The study showed that approximately 6.5 meteors hit Jupiter every year, a value at the low end of previous estimates.

"Constraining this number is important to improve our expectancies of observing large impacts with the planet, such as the Shoemaker-Levy impact in 1996 and the 2009 impact," says Ricardo Hueso of the University of the Basque Country in Spain. "That will allow us to know more about the current architecture of the outer Solar System and the role of Jupiter in protecting the Earth from comparable impacts."

To contribute to the search for impacts on Jupiter, visit www.astrosurf.com/planetessaf/doc/project_detect.shtml.

The purest galaxy in the cosmos

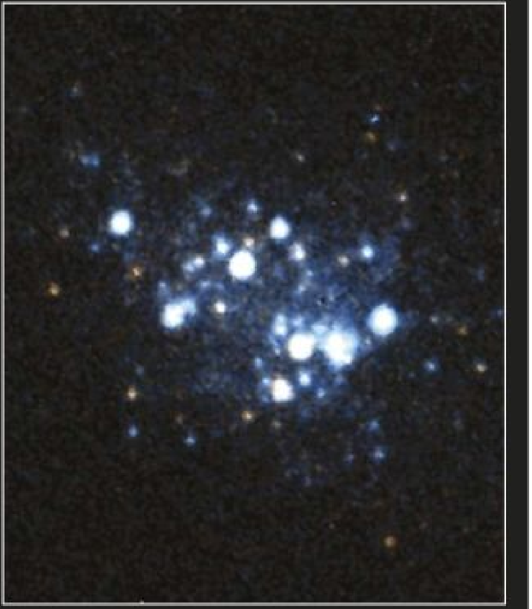
The stellar collective could help scientists test the Big Bang model

A DWARF GALAXY has been found to have the lowest amount of metals – which in astronomy means all elements heavier than helium – ever seen in a gravitationally bound system of stars. Such objects are important to test theories about the Big Bang, which depend upon the levels of hydrogen and helium in the early Universe. This is difficult to measure as over time, space has become polluted with the heavy metals formed by later stars.

"There are relatively few ways to explore conditions at the birth of the Universe, but low-metal galaxies are the most promising," says John J Salzer from Indiana University Bloomington.

As the galaxy, nicknamed Leoncino, is only 30 million lightyears away, researchers can get a clear view of it, allowing them determine its composition by measuring its spectrum. "Low-metal galaxies are extremely rare, so we want to learn everything we can," says Salzer.

https://www.indiana.edu



▲ Leoncino, officially designated AGC 198691, as imaged by the Hubble Space Telescope

TSUNAMIS WASHED OVER ANCIENT MARS

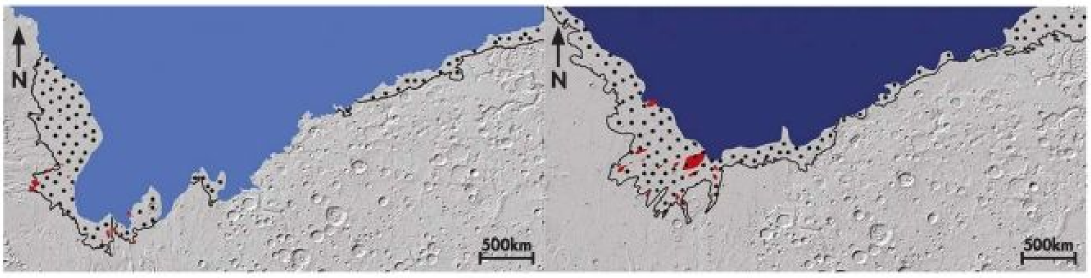
SCARS IN AN ancient shoreline running through Mars's northern plains show that two tidal waves swept over the planet early in its history. New evidence suggests that a pair of large meteorites struck the surface millions of years apart, raising tsunamis as high as 120m in an ocean that was cold and briny – and perhaps a haven for life.

"About 3.4 billion years ago, a big meteorite impact triggered the first tsunami wave. This wave was composed of liquid water," says Alberto Fairén, principal investigator at the Center of Astrobiology, Madrid.

By the time the second impact hit, Mars's temperature had dropped significantly. The marks left behind in the Martian landscape indicate the second tsunami froze where it reached farthest inland and never returned to the sea, suggesting the ocean was partially frozen and rich in salts.

"Cold, briny waters may offer a refuge for life in extreme environments as the salts could help keep the water liquid. If life existed on Mars, these icy tsunami lobes are very good candidates to search for biosignatures," says Fairén.

http://astro.cornell.edu

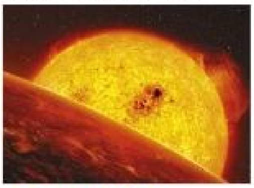


▲ The extents of the older (left) and younger (right) Martian oceans, with the reach of their tsunamis marked by the dotted surface; onshore wave heights are estimated to be 50m, greater than those that struck Sri Lanka in 2004

NEWS IN BRIEF

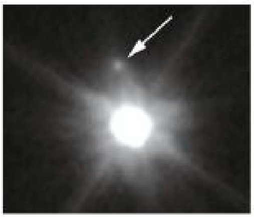
RED GIANTS MELT FROZEN WORLDS

Simulations have shown that the region where liquid water oceans can exist on planets moves farther out as a star ages and expands to become a red giant. This could allow previously iced-over planets and moons, such as Europa and Enceladus in our own Solar System, to melt. "Such worlds around small red stars could become habitable for billions of years, maybe even starting life, just like Earth," says Lisa Kaltenegger from the Carl Sagan Institute.



MAKEMAKE'S MISSING MOON

A new moon has been found around Kuiper Belt object Makemake. It is only 180km across and 1,300 times fainter than the dwarf planet. Scientists have looked for a moon before, but its orientation helped it to hide. "Our preliminary estimates show that the moon's orbit seems to be edge-on, and that means that often when you look at the system you are going to miss the moon because it gets lost in the bright glare of Makemake," says Alex Parker from the Southwest Research Institute in Colorado.



CUTTING EDGE

Our experts examine the hottest new research

The flushes of stellar youth

An odd X-ray outburst hints at a missing gas cloud

TAKE 27 LTD/SCIENCE PHOTO LIBRARY

▲ Scientists would expect to find a cloud of surrounding gas for such an outburst to occur – so where is it around CX330?

Chris Britt of Texas Tech University and colleagues have an excellent puzzle on their hands. It comes in the form of an object with the charming name CX330, first spotted during a survey taken by NASA's Chandra X-ray Observatory.

The telescope was mapping the Milky Way's bulge when it found a bright source of X-rays. Those observations were made in February 2009, and the source shows up again in observations taken by the infrared WISE satellite a little more than a year later. Yet it's invisible in infrared observations made with the more powerful Spitzer Space Telescope in 2007. Sometime between 2007 and 2010, CX330 got brighter in the infrared by over six magnitudes – reflecting an increase in luminosity of more than 300 times.

Clearly something spectacular is happening, and it hasn't ended yet. At least five years after the initial outburst, CX330 is still bright in both infrared and visible light, which has allowed the team to study it. Critically, they found clear signs of hydrogen in the spectrum obtained from the source, and from there could measure the distance – this is a local source, located in our own Galaxy. Studying the gas also indicates that it is rushing outwards, perhaps as fast as 700km/s.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

So what exactly is it? The most common form of transient event in the Milky Way would be a classical nova, the result of a transfer of gas between an ordinary star and a neighbouring white dwarf in a binary system. As gas builds up on the white dwarf it can get dense enough to begin nuclear reactions, causing the system to brighten until the fuel is exhausted again.

Such systems can repeatedly brighten and then fade, but it would be unusual for one to remain as bright as CX330 has for as long as it has. It's not totally unheard of for novae to have outbursts that last as long as this, but not to then show the rapid changes of brightness which are still observed in CX330.

Instead, the authors think this is a young system, rather than the old stars required for a classical novae. Young stellar objects are unstable in the first flush of their lives, and outbursts have been seen in dense regions of star formation where clusters of stars are forming.

> "Between 2007 and 2010, CX330 got brighter in the infrared by over six magnitudes"

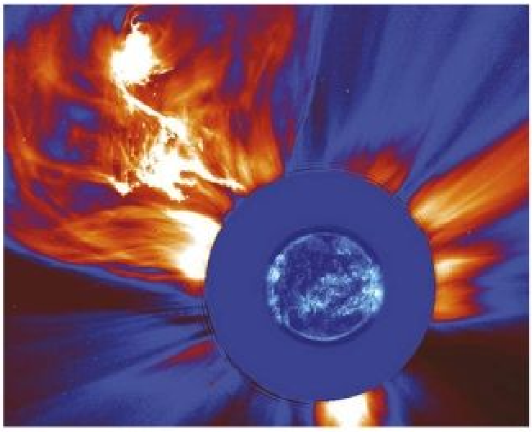
Could something similar be happening here? An outflow of material due to the powerful stellar wind of a massive young star would explain the observed outflow, the detection in X-rays of hot gas and the fact that the object has probably been misbehaving for the best part of a decade.

But this would make CX330 an isolated example of a process that has only ever been seen in denser regions. Such outbursts are normally spotted by an interaction between the outflow and the cloud of surrounding gas. Here, though, away from a large cluster or nebula, there is no such cloud. Somehow a massive star has formed and the cloud from which it was born dispersed in under a million years. Such rapid change for an isolated system is surprising, and if the theory is right then watching CX330 may still reveal further secrets of star formation.

CHRIS LINTOTT was reading… *Discovery of a long-lived, high amplitude dusty infrared transient* by C T Britt et al
Read it online at https://arxiv.org/abs/1605.05321

Solar flares could predict CMEs

They don't always occur together, but some activity can trigger both



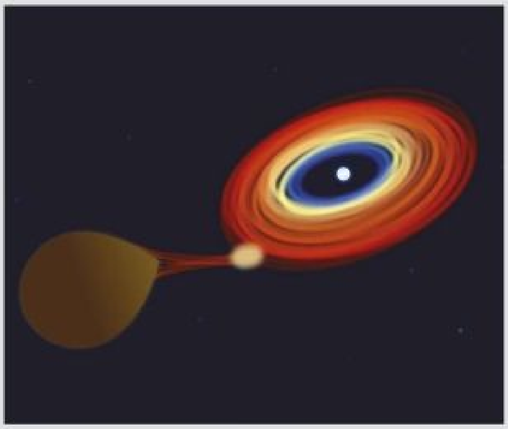
▲ CMEs are among the most violent solar events; this one was snapped by the SOHO mission in 2002

ACCORDING TO A new study, coronal mass ejections (CMEs) could be predicted by observing solar flares. Researchers have been looking for a way to forecast CMEs as the enormous clouds of magnetic flux and plasma they produce can disrupt satellites and harm astronauts. The outbursts are caused by fluctuations in the Sun's magnetic field, just like smaller and more localised solar flares, though the two do not always occur together. However, some activity can trigger both and a new study from Stanford University has shown that the flares generated by these events have markers in their magnetic properties. Astronomers can use these markers to determine if such activity has occurred and a CME is imminent.
http://sdo.gsfc.nasa.gov

CANNIBAL STARS MAKE BROWN DWARFS

FOR THE FIRST time, a white dwarf has been discovered stripping its companion star, taking 90 per cent of its mass and shrinking what was once a normal star to a brown dwarf. The companion star is unlike most brown dwarfs, which never have enough mass to start combustion to begin with: it was once aglow, before being cannibalised by the more dense white dwarf.

"Our knowledge of binary evolution suggests that if the companion star can survive the transition, brown dwarfs should be common in this type of system. Our results now confirm that the successful transformation of a star to a brown dwarf is possible," Juan Venancio Hernández Santisteban from the University of Southampton.
https://www.eso.org/public/teles-instr/paranal



The faint binary system home to this unusual discovery is J1433, located 730 lightyears away

Looking back The Sky at Night

July 2008

On 7 July 2008 the team on *The Sky at Night* looked at the latest news from NASA's Phoenix lander on Mars. It had touched down in the Red Planet's arctic region on 25 May that year.

One of the lander's first tasks was to use a robotic arm to dig down through the topsoil layer to confirm the presence of underground water ice, evidence of which had been found by the Odyssey mission in 2002. But the biggest surprise was the discovery of perchlorates, a chemical that could be broken down into oxygen and fuel for future missions. Years later the Curiosity mission found perchlorates elsewhere on the planet, suggesting that the chemical might be spread across Mars's surface.

The mission ended after 152 Martian days of operation, when a dust storm covered over the probe's solar panels. Contact was lost on 10 November.

▲ Phoenix returned over 25,000 images from the Red Planet

NEWS IN BRIEF

FOUR PLANETS MOVE IN SYNC

A planetary system with four gas giants in lockstep has been discovered. For every three orbits of the outermost planet, the second orbits four times, the third six times and the innermost eight. Such correlations are known to happen, but have only been seen between pairs of planets, never four at once.

It's thought that these lockstep configurations happen as planets migrate through the planetary system after formation – their gravitational interplay pulling them into such a pattern. Scientists suspect that our own gas giants were once in a similar arrangement, but collisions with asteroids, tidal forces and other interactions moved them out of line with each other.

ISS MARKS 100,000TH LAP

The International Space Station reached a major milestone on 16 May: its 100,000th orbit. Since the launch of its first module, Zarya, on 20 November 1998, the ISS has travelled more than 4.1 billion km. "An amazing feat of science, engineering and international cooperation," said UK astronaut Tim Peake of the achievement.

SOHO (ESA/NASA)/S. HILL, RENE BRETON/UNIVERSITY OF MANCHESTER, NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA/TEXAS A&M UNIVERSITY, ESO/L. CALÇADA/P. DELORME/NICK RISINGER (SKYSURVEY.ORG)/R. SAITO/VVV CONSORTIUM, ESA/NASA

CUTTING EDGE

Our experts examine the hottest new research

The secret of Jupiter's blush

An ultraviolet experiment may have finally revealed why the Great Red Spot bears a distinctive ruddy hue

Jupiter's Great Red Spot has been swirling since at least 1830

ISTOCK

Jupiter is painted in a beautiful palette of beiges, yellows and browns, marking out the belts and zones of circulation within the atmosphere. But within the largest storm in the Jovian atmosphere, a different colour is vibrantly apparent. The Great Red Spot is tinted with a deep orange-red pigment, but for many years the actual chromophores responsible have been a mystery. Exactly what compounds are in the air to flush it such a deep red, and why are these molecules only present in the Great Red Spot?

A clue to what's going on is the fact that the Great Red Spot is one of the tallest vortex structures on the planet – the top of the storm towers about 6km above the surrounding cloud deck of ammonia. So it is commonly assumed that this powerful vortex sucks gas up from deeper in Jupiter's atmosphere, which at these much higher altitudes becomes exposed to solar ultraviolet radiation. Ultraviolet exposure drives a lot of chemistry, breaking apart certain molecules so that they react together to form new compounds. Over the years, a number of ideas have been proposed as to what these red-coloured products might be, but very few experiments have actually been conducted to try to confirm these guesses.

This is where Robert Carlson of NASA's Jet Propulsion Laboratory and colleagues come in. Not only have they analysed visible spectra from several missions (including Cassini and the Hubble Space Telescope) to determine what the exact colour of the Great Red Spot actually is, but they've also created compounds in the lab that match this convincingly.

Carlson filled an experimental chamber with gases recreating the Jupiter's upper atmosphere – ammonia drawn up from Jupiter's depths through the action of the Great Red Spot's vortex, mixed with acetylene settling down from higher altitude – and blasted them with an ultraviolet lamp. What they found, is that over time, the walls of the chamber become coated with a yellowy-orange solid residue.

> "The top of the storm towers 6km above the surrounding cloud deck of ammonia"

Once this residue was coated over the tiny ammonia particles in the Jovian cloud tops, its colour would shift as it scattered the sunlight. To determine whether this chemistry could account for the colour of the Great Red Spot, Carlson and his team calculated what reflectance spectrum would be produced in this more complicated, real situation. And to their satisfaction, the researchers found a pretty convincing spectral match. They had created the red pigment of the Great Red Spot in their lab.

The exact composition of this residue is quite complicated, but if you're a chemist you'd readily recognise aliphatic azine, azo, and diazo compounds. But this elegantly simple experiment has demonstrated that the action of solar ultraviolet on ammonia and acetylene is indeed the cause of the blushed cheek on the face of Jupiter.

LEWIS DARTNELL is an astrobiologist at the University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading… *Chromophores from photolyzed ammonia reacting with acetylene: Application to Jupiter's Great Red Spot* by R W Carlson et al **Read it online at http://www.sciencedirect.com/science/article/pii/S0019103516001494**

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What's on

Our pick of the best events from around the UK

PICK OF THE MONTH

▲ Bright lights and stargazing combine at the new Bluedot festival in Cheshire

Bluedot at Jodrell Bank

Jodrell Bank Observatory, Cheshire, 22-24 July

Bluedot is a brand new festival, hosted at one of the world's most famous observatories, offering a weekend of live music and camping in the shadow of the Lovell Telescope alongside a range of science and astronomy events.

Prof Brian Cox and comedian Robin Ince bring their hit Radio 4 show *The Infinite Monkey Cage* to the festival, while space travel expert and *Stargazing Live* roadshow presenter Helen Keen hosts a space-themed quiz.

Prof of Astrophysics at the University of Manchester Tim O'Brien leads the late-night stargazing sessions with *The Sky at Night* presenter Pete Lawrence. And the UK Space Agency hosts a panel of experts and special guests to discuss Tim Peake's Principia mission and the future of British space travel.

Other speakers at the festival include ESA's Dr Matt Taylor, who provides an update on the Rosetta mission to comet 67P/Churyumov-Gerasimenko, Prof of Astrophysics at Jodrell Bank Ben Stappers, and Teresa Anderson, director of the Jodrell Bank Discovery Centre.

Bluedot features a full programme of live bands and DJs, including a live light show by Brian Eno that incorporates the Lovell Telescope. **www.discoverthebluedot.com**

BEHIND THE SCENES

THE SKY AT NIGHT IN JULY

BBC Four, **10 July**, 10pm (first repeat **BBC** Four, **14 July**, 7.30pm)*

NASA's Juno probe arrives at Jupiter on 4 July, after a near five-year journey

MISSION TO JUPITER

The team report from NASA's Jet Propulsion Laboratory in Pasadena, California as NASA's Juno probe arrives at Jupiter. Chris and Maggie will be analysing the spacecraft's journey to the gas giant and speaking to Juno scientists about the importance of the mission and what they hope to discover.

Check www.bbc.co.uk/skyatnight for subsequent repeat times

BLUEDOT/JODRELL BANK, STFC, DAVID ROTHERY

Seeing the Universe in all its light

Science & Technology Facilities Council, Daresbury Laboratory, Warrington, 9 July

This travelling astronomy exhibit showcases the big telescopes of the world and is open to the public for one day as part of STFC's Open Week at Daresbury Laboratory. It includes scale models of the most famous scopes on Earth, interactive and 'hands-on' exhibits, and historical science papers courtesy of the Royal Astronomical Society. Admission is free but registration is required. **www.stfc.ac.uk**

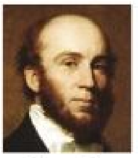
New views of the Sun's innermost planet

Hampshire Astronomical Group, Clanfield Memorial Hall, Clanfield, Hampshire, 8 July, 7.45pm

Many questions remain for ESA's BepiColombo mission to Mercury, but thanks to NASA's Messenger probe we now know more about the closest planet to the Sun than was ever possible from ground-based astronomy. In this talk for Hampshire Astronomical Group, Mercury expert Prof David Rothery (pictured) reveals what we have learned so far. Admission is £3. **www.hantsastro.org.uk**

Charles Piazzi Smyth

Astronomical Society of Edinburgh, Augustine United Church, Edinburgh, 1 July, 8pm



Charles Piazzi Smyth (pictured) was Astronomer Royal for Scotland at Edinburgh's Calton Hill from 1845 to 1888. In this talk for the Astronomical Society of Edinburgh, Dr Bruce Vickery turns to his own research of local archives to reveal less well-known insights into Smyth's multi-faceted life. Admission is free; go online for more information. **www.astronomyedinburgh.org**

MORE LISTINGS ONLINE

What's on

All Events

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.

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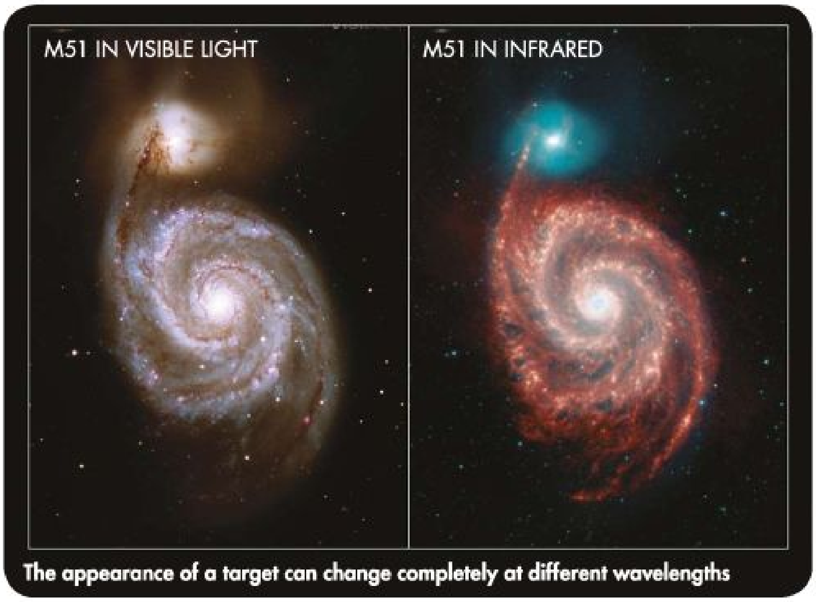
A PASSION FOR SPACE

with **Maggie Aderin-Pocock**

The Sky at Night presenter explains why we observe at all wavelengths of the electromagnetic spectrum



The appearance of a target can change completely at different wavelengths

NASA/JPL-CALTECH/R. KENNICUTT (UNIV. OF ARIZONA)/DSS

In June's programme we have been looking at and celebrating the wonderful Whirlpool Galaxy, M51, and discovering what is revealed when it is analysed in different parts of the electromagnetic spectrum – the light fantastic. Electromagnetic waves are a form of energy that have both an electric and magnetic component. They're different from mechanical waves since they're one of the only things that can propagate long distances through the vacuum of space. And as we are surrounded by that vacuum, if we want to see what is out there we are currently reliant on the electromagnetic spectrum.

I have spent much of my career working in different parts of the electromagnetic spectrum. My trip with the light fantastic began where it begins for most, with visible light and the 'mark one eyeball'. I began looking up at the night sky at an early age and wanted to enhance my view, so I built my own telescope to gather more light than I could with just my eyes. This started me in a career in instrumentation, and as well as visible light I have used radio waves, infrared and ultraviolet to understand our surroundings, both here on Earth and out in space.

As some electromagnetic wavelengths are absorbed by our atmosphere we need to get above it to capture them, so we build space instrumentation. But in astronomy what do we gain by looking at the various parts of the spectrum? Different types of electromagnetic radiation are generated by specific types of interaction between matter. At the low energy end, radio waves are generated by the twisting and spinning of molecules: the Whirlpool Galaxy observed through a radio telescope reveals areas of cool gases such a carbon dioxide.

Hidden depths

Moving up in energy we get infrared waves, which are caused by the collision of atoms and the exchange of electrons. This reveals areas of the Whirlpool Galaxy where small, cool, red stars reside and these make up the majority of the galaxy. Up the energy again and we get to visible light, this is caused by the movement of electrons within an atom, which causes the absorption and emission of photons. This part of the spectrum reveals stars not too dissimilar our own Sun in M51.

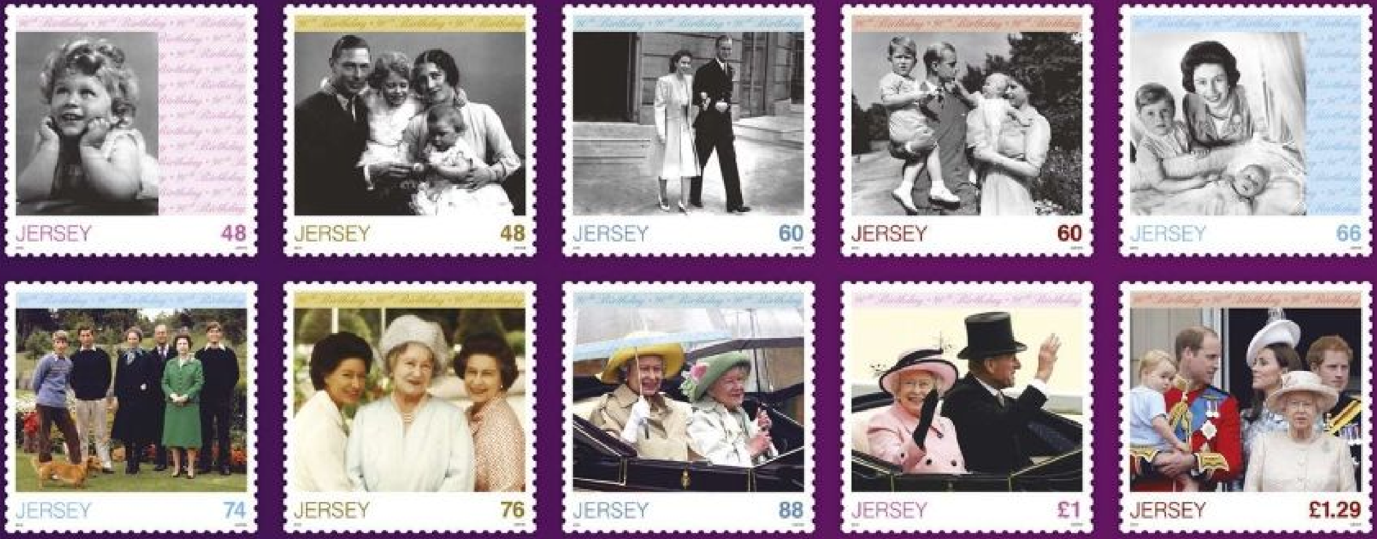
Now we come to the higher energy areas of the spectrum – ultraviolet, X-rays and gamma rays. Ultraviolet waves show M51's larger, hot blue stars, their energy generated by ionised gases where free electrons can exist. X-rays show us the hot areas of galaxies. Observing in these energies elsewhere reveals the locations of things like black holes, neutron stars and binary star systems, which all emit X-rays. At the top end of the light fantastic we get gamma rays, highly energetic waves that are produced by radioactive atoms and nuclear explosions. Supernovae, neutron stars, pulsars and black holes are all sources of celestial gamma rays.

It is only by looking at the combination of these different energies that we can get a true understanding of a galaxy that sits some 23 million lightyears away from us. Ⓢ

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

A Royal Occasion

Commemorate Her Majesty Queen Elizabeth II's 90th birthday with these wonderful Collectables from Jersey Post



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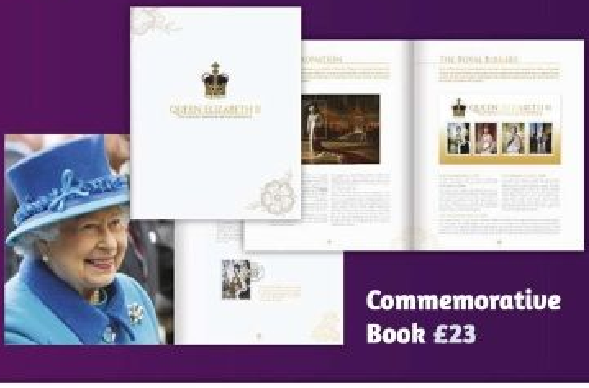

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JON CULSHAW'S EXOPLANET EXCURSIONS

Jon finds himself in Cygnus, where he discovers a lava world as hellish as they come

There's an exoplanet of the most extraordinary extremes in existence around the star Kepler 78, 400 lightyears from Earth in Cygnus. It's a world we'd consider to be utterly hellish.

Kepler 78 is a young star, about one-sixth the age of our Sun. Orbiting it some 40 times closer than Mercury to the Sun is the molten lava planet Kepler 78b. The desperately hot temperatures here mean any atmosphere around this rocky, iron-rich planet would have long since boiled away.

Another extreme of this hell planet is the dizzying speed it orbits the parent star Kepler 78. Earth years, we know, last 365 days – enough for months, seasons and other intervals whereby we can punctuate life conveniently. But an entire year on Kepler 78b takes just 8.5 hours! If Earth years lasted 8.5 hours I doubt I could cope with the usual torrent of Christmas songs with such repetitive frequency.

This is a fairly large planet by our Earthly standards. It is 1.12 times Earth's radius and about 1.7 times as massive. It's thought the core of this planet could make up 40 per cent of its total mass. Gravity is stronger here too, so we'd feel marginally heavier on this world, though with surface temperatures between 2,030°C and 2,830°C we wouldn't be aware of that for very long.

After nestling my ship, the Perihelion, on the night side of a moon orbiting Kepler 78b, I have a splendid view of the simmering, molten majesty of this extraordinary hell world. The ship's heat shields are set to maximum protection and here we're able to view the combination of planetary extremes with fascinated serenity.

At our present point we see Kepler 78b rising with a beautifully distinct crescent, rather like our Moon a day after its new phase. Shining with an incandescent orange, underlit by the parent star. The terminator line we see from our position is beautifully sharp.

Quite amazing too, is the night side of Kepler 78b contrasting with the sleek bright curve of the illuminated crescent. We're used to the silvery-blue earthshine seen at times of the crescent Moon. Observing Kepler 78b we see a glowing soft ochre brown as the planet's molten surface illuminates the planet's night side.

It's a good moment to contemplate some of the mysteries of this world. According to our knowledge of planetary system formation, Kepler 78b couldn't have formed in its current place. It's also a mystery how it may have migrated from farther out. I always find a good mystery most alluring: it's a good frame of mind in which to observe the pale, peachy, shimmering light which belies the hellish conditions and immense orbiting pace of Kepler 78b around its parent star.

It's believed eventually, Kepler 78b will be sucked into its parent star and destroyed. So those vaporisingly hot 2,830°C temperatures are set to rise higher still, although not for another three billion years yet.

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS

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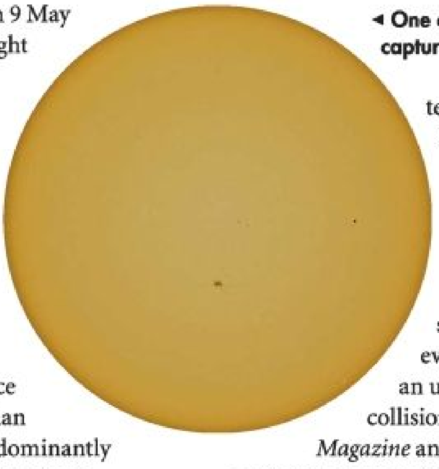
MESSAGE OF THE MONTH

The best kind of astro imaging collaboration



◄ One of the many images Sarah-Jane captured with Andrew's setup

For me, the transit of Mercury on 9 May was always going to be the highlight of the astronomical year. Your article in the May issue, (Astrophotography, page 60) gave some excellent advice, particularly with regards to framing the image and exposure times. Everything was planned; even the sky was forecast to be clear. What could possibly go wrong? Having to attend a meeting at our head office on the day of the transit rather than working from home, which I predominantly do, is what! My wife, Sarah-Jane, is not an observer, but with a crash course in telescope operations she agreed to help. I have an 8-inch Newtonian telescope fitted on an HEQ5 Pro mount with a DSLR camera – not an ideal first telescope, but the day before the transit I showed Sarah-Jane how to control the telescope and operate the camera, she taking copious notes throughout. On the day, she captured several hundred images of the event, despite having to deal with an unexpected telescope and pier collision. Thanks to *BBC Sky at Night Magazine* and importantly, my wife, for capturing such great images of the transit!

Andrew Richens, Long Sutton, Lincolnshire

Fantastic picture Andrew. I'm delighted that your teamwork paid off! **– Ed**

Marvellous models

My seven-year-old granddaughter Megan made me models of Earth, Jupiter and a rocket during her school holidays. She loves anything to do with the stars and planets: her favourite is Saturn and she can name all eight major planets in the Solar System as well as some dwarf planets. Megan explained that the models were a journey from Earth to Jupiter and even painted a Great Red Spot on her model of the gas giant.

Ian Rampton, via email

Creative masterpieces, Ian! I particularly like the gold spacecraft. **– Ed**

Megan's masterpieces; no doubt a career in spacecraft design awaits

I think I see a pony...

Whilst browsing through the Hotshots section in the June edition (page 28) with my five-year-old daughter, we came across the Orion Mosaic and I asked her what she thought the black patch on the left looked like. After a few seconds, she had a sudden realisation: "Oh, it looks like a horsey," she said. "And if I look really closely, I can see some ears!" Get them hooked early with the prospect of horses in space!

Lee Holden, Lancashire

Your daughter would surely love to see the menagerie of animals in the Rosette Nebula, Lee. There's a cheetah, a donkey, a dog and even an elephant! **– Ed**

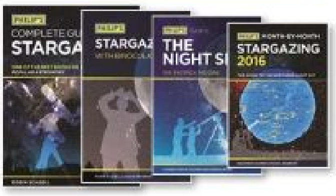
Looking for collaborators

I'm 16 and have been interested in astronomy for several years. I want to get into astrophotography and in particular image processing. I have access to several software applications including Photoshop, DeepSkyStacker, and RegiStax, but my basic refractor and DSLR setup, coupled with light-polluted skies and bad weather, means

This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philips: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Robin Scagell and David Frydman's *Stargazing with Binoculars* and Heather Couper and Nigel Henbest's *Stargazing 2016*

PHILIP'S



SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: What was the moment that got you into astronomy?

@selector_cools Sitting on a roof watching the constellations was the best thing to do in the West Indies.

Andy Dunmore When Patrick Moore came to my junior school in the late 60s to give a presentation and sign books. Been hooked and fascinated ever since. Living near Selsey I often have the occasional chat and meeting with Pete Lawrence of *The Sky At Night* fame as he's local to me!

Alfredo Balreira My first interest came when my father showed me Sputnik

SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

crossing the skies at night. Later, the Hubble images caught me and since then I've been imaging using a small backyard observatory.

@arkyLyng I was on the terrace during Perseid peak and saw many meteors blazing across the sky, I was so awestruck.

Keith Moseley It was being given a colourful book on the Solar System and a small telescope. However, a really memorable moment occurred some years later. In the early 1970s industrial action resulted in power cuts; one night Birmingham's lights were turned off and the Universe was revealed in all its glory. We're so used to light pollution that its sudden disappearance is truly breathtaking.

John Pilbeam I was watching TV and my parents called me to go outside and look at the Moon through my brother's 40mm refractor... the view was unforgettable and from that moment I was hooked!

Julie Morton-Smith I bought a book called *I-Spy the Sky* for sixpence in the 1960s and discovered that stars had names. I took the book with me on a stargazing trip to the summit of Mauna Kea in Hawaii in 2010.

@Damien_Wev I was inspired by the BBC's 2013 *Stargazing Live* show. I am now a member of a local society and hooked on astrophotography.

I am unable to capture any decent images to edit. Reading your May issue, I noticed that the winning Hotshots (page 29) image was the result of a collaboration between people from different countries, one who takes the images and the other who processes them. I wonder if you have any idea of any websites or people who may be willing to share their unprocessed images for others to edit, so that I can practise and learn new editing skills.

James Bannister, via email

A very interesting idea, James. Pop the question on our forum (www.skyatnightmagazine.com/forum) and I'm sure you'll hear back soon. Also visit http://pds-imaging.jpl.nasa.gov to find image data from NASA spacecraft that you can download and process yourself. **– Ed**

Cheap shots

▲ **One of Kim's lunar shots and the modest setup used**

I would dearly love to take photos of deep-sky objects and the planets – especially Jupiter, my favourite – but a DSLR is currently beyond my budget, as is a scope larger than my Celestron Astromaster 130EQ. However, I set up my scope with a Baader Clickstop camera adaptor, my 12 year-old Olympus C-220 point and shoot camera and a motor drive to try some afocal shots of the Moon through a 9mm Celestron X-Cel eyepiece with a Baader neutral density filter added. I'm really pleased with the detail, especially the craters Tycho, Copernicus and Plato! All the equipment used was relatively cheap and won't break the bank. Of course even more detail would be visible with a higher-spec setup, but if there are any budding astrophotographers who worry about the cost of getting into the hobby, its good to know that cheap and cheerful can still result in some great images.

Kim Ralls, via email

Quite right, Kim. Even with modest equipment, astrophotography can be very rewarding. **– Ed**

Universal faith

Thanks for your interesting article 'When Religion meets ET' (May 2016, page 73), but I question whether Christianity is quite so parochial as suggested. Jesus is not simply a decent bloke born to a nice girl on a relatively insignificant planet. Far from being a mere local hero, mainstream Christianity proclaims him as the eternal son of God, through whom and for whom the whole Universe was created and is sustained. If there are sentient beings on distant planets they will be too far away for us to visit; but if they have souls then perhaps the same son of God could visit them, take their form and bring them redemption also? Just a speculation, but then so is the existence of extraterrestrials – at least at present! As a Christian minister, keen astronomer and sci-fi enthusiast I don't believe the prospect of finding extraterrestrials will shake my faith.

Rev Gary Tubbs, Ulverston, Cumbria

Thanks for the theological viewpoint, Gary. **– Ed**

Neoprene dream

Inspired by the home-made solar filter in last month's Interactive (page 24), here's my own creation. I recently bought a Sky-Watcher Skymax 127 SynScan Go-To telescope and wanted to avoid it dewing up. I was unable to justify further expense so I decided to make my own dew shield. I realised that catering-size coffee tubs would be the prefect size and first removed the base of the tub and any sharp edges. I got some self-adhesive neoprene of varying widths and thicknesses and stuck some 20x5mm neoprene tape around the edge so it would fit snugly on the end of the scope. Then I wrapped a larger sheet of neoprene around the outside, followed by another sheet on the inside to cover the reflective surface. A few more neoprene strips inside stopped the shield sliding too far over the tube and all was done. The black neoprene looks great with the finish of scope, and there is no reason why it couldn't further adapted by adding a heating strip.

Ben Kent, via email

Admirable ingenuity, Ben! Did you drink all that coffee? **– Ed**

▲ **Ben's home-made dew shield keeps his optics clear**

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The perfect addition to your stargazing, *BBC Sky at Night Magazine* is your practical guide to astronomy, helping you to discover the night skies, understand the Universe around us and learn exciting techniques for using your telescope.

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Motion of the stars

Capturing stellar motion is a great way to take your next step in night sky photography. **Jamie Carter** reveals how

MORE AMAZING ASTRO IMAGES IN IAPY 2016

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

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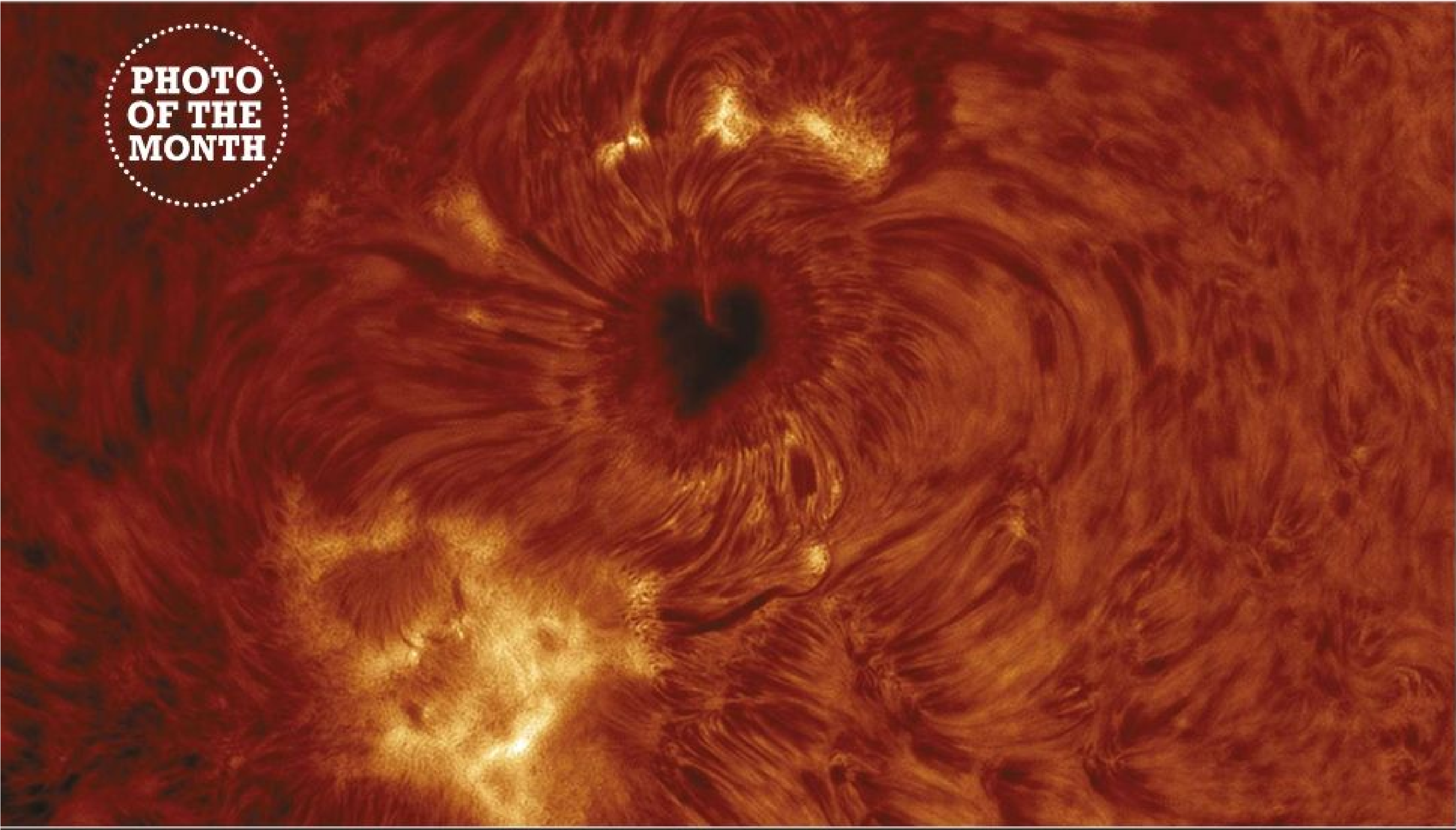
Hotshots

This month's pick of your very best astrophotos

YOUR BONUS CONTENT

A gallery containing these and more of your stunning images



▲ Heart and Sol

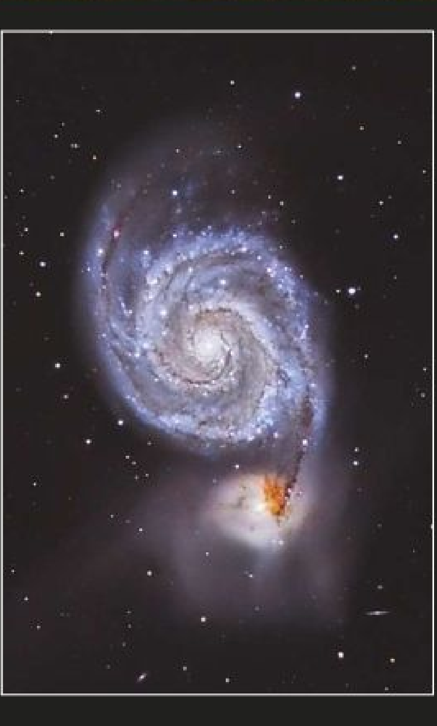
EWAN HOBBS, HASTINGS, 13 APRIL 2016

Ewan says: "I decided to take the image because sunspot AR2529 was huge and putting on quite a show. I was recommended the Daystar Quark eyepiece and without this advice I never would have taken up solar imaging. This is by far my best image to date and I think I will continue to pursue solar imaging, as new tech is opening the door to those on a lower budget."

Equipment: The Imaging Source DMK 21AU618 mono CCD camera, TecnoSky 6-inch refractor, Sky-Watcher AZ-EQ6 GT mount, Daystar Quark chromosphere eyepiece, Baader D-ERF solar filter.

***BBC Sky at Night Magazine* says:** "Ewan's passion for solar imaging meant he was aware of AR2529's increased activity, and his diligence has paid off. This is a fantastic image, with the heart shape crisp and clear, and great texture and detail in the surrounding areas."

About Ewan: "If it's sunny I will normally be imaging in the rear garden. I can be out most of the day trying to get that one really good capture, but it's worth the time and effort experimenting to try things outside of the norm."

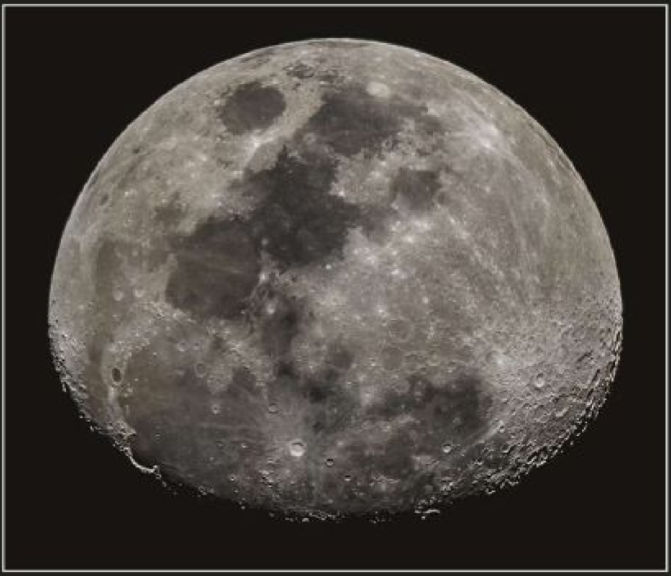


◀ The Whirlpool Galaxy

DAVID ATTIE, ABU DHABI, UAE, 9 APRIL 2016

David says: "I took this photo in the Liwa Desert. The light pollution is so bad in Abu Dhabi that driving 140km is the only way to get a decent sky."

Equipment: Moravian G2-4000 CCD camera, Celestron C11-A XLT Schmidt-Cassegrain, Sky-Watcher AZ-EQ6 GT mount.

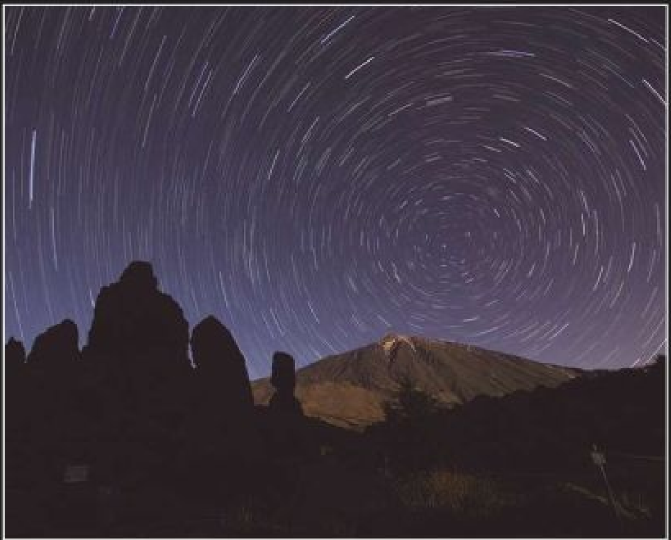


◀ The Moon

PAUL SHEPPERD, HAMPSHIRE, 17 APRIL

Paul says: "I love trying to get as much detail in my Moon photos as possible and found the perfect opportunity to try some image stacking. I took eight photos at different ISO settings then manually stacked them on my PC to get a true HDR image."

Equipment: Nikon D7200 DSLR camera, Sky-Watcher Explorer 150 PDS Newtonian reflector, Sky-Watcher EQ5 PRO SynScan mount.

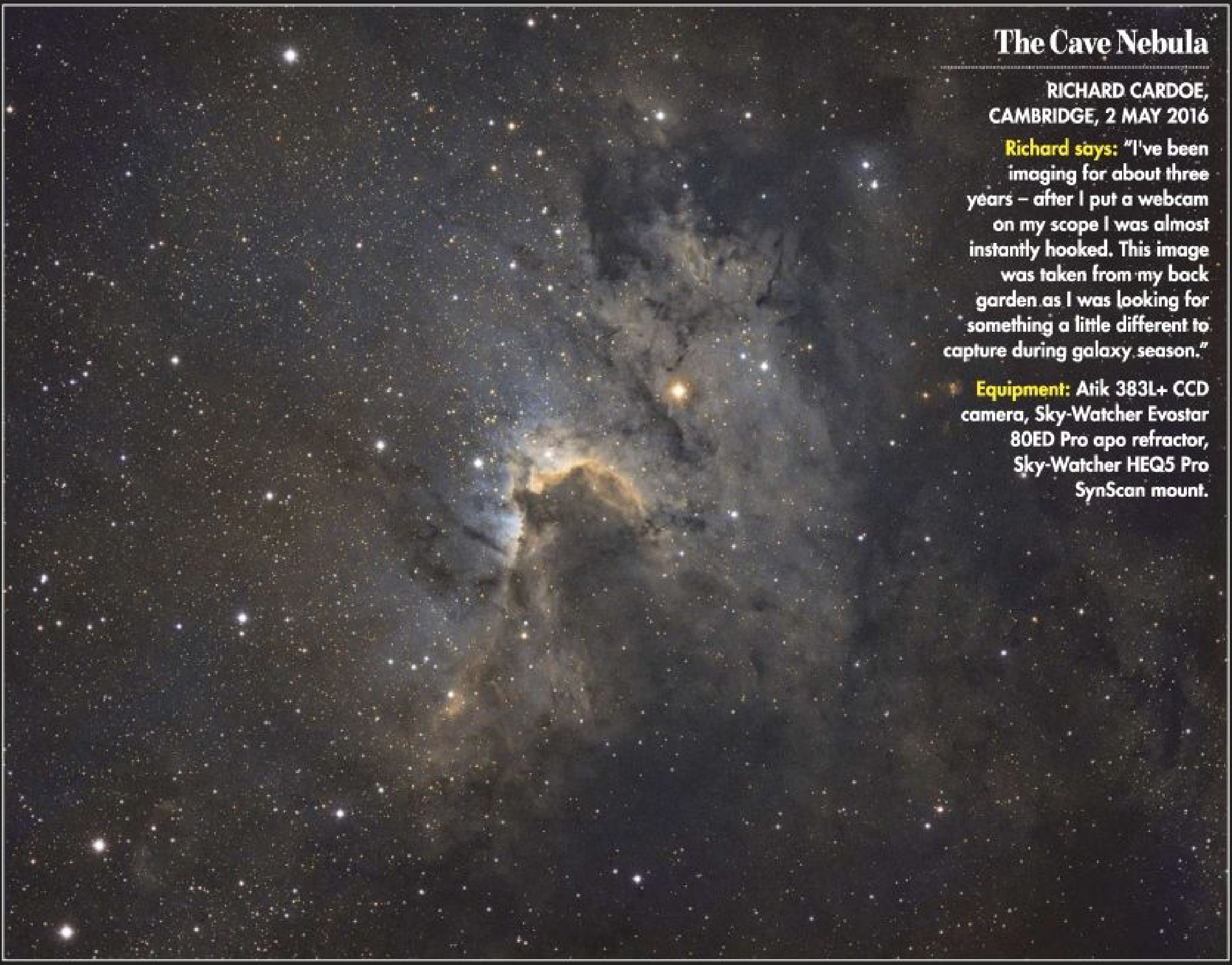


Star trails ▶

RICHARD HARRISON, MOUNT TEIDE, TENERIFE, 29 MARCH 2016

Richard says: "I visit Tenerife once a year and always have a couple of night shoots up Mount Teide. It has one of the darkest skies available and is one of my favourite places. It looks like a scene from a sci-fi film and the rock formations help make interesting photographs."

Equipment: Pentax K-3 DSLR camera, Pentax fisheye lens.



The Cave Nebula

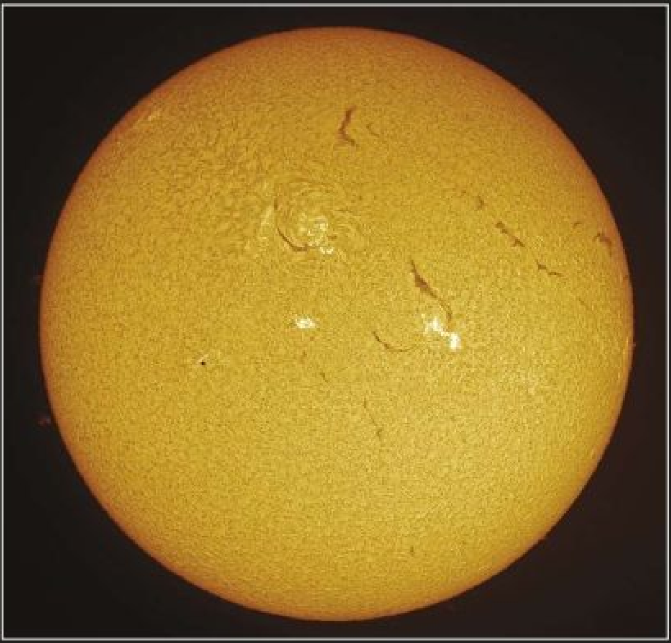
RICHARD CARDOE, CAMBRIDGE, 2 MAY 2016

Richard says: "I've been imaging for about three years – after I put a webcam on my scope I was almost instantly hooked. This image was taken from my back garden as I was looking for something a little different to capture during galaxy season."

Equipment: Atik 383L+ CCD camera, Sky-Watcher Evostar 80ED Pro apo refractor, Sky-Watcher HEQ5 Pro SynScan mount.

Hotsh●ts MERCURY TRANSIT SPECIAL 9 MAY 2016

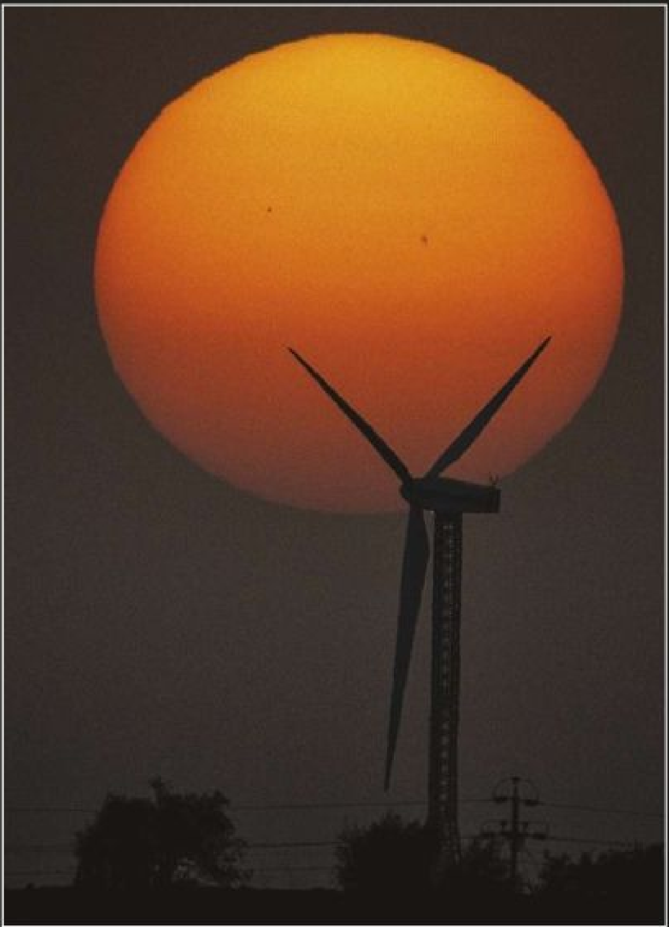
Many of you sent in your amazing images of the Mercury transit in May. Here we present some of our favourite captures



▲ Antoine Thibault, Bern, Switzerland

Antoine says: "I decided to drive east to maximise my chances of getting sunny spells, but after two hours the clouds were still thick so I drove back. Eventually I realised I might have a brief opportunity, so I stopped at a rest area on the highway just in time to get one shot."

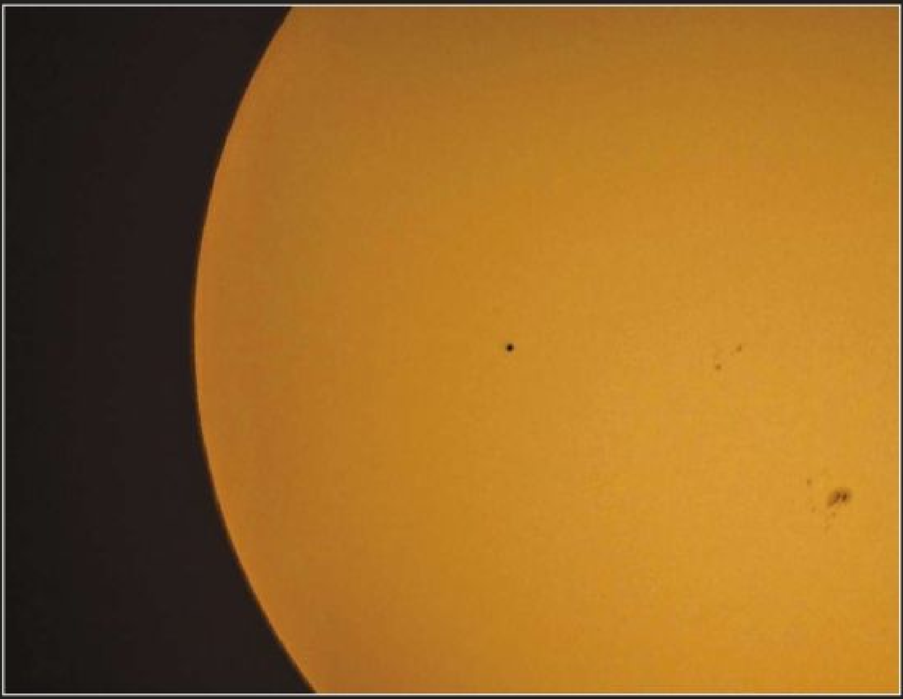
Equipment: Basler mono camera, Sony IMX174 sensor, Astro-Physics 4-inch refractor, Coronado SolarMax II 90mm hydrogen-alpha scope.



▲ Atish Aman & Abhinav Singhai, Jaisalmer Wind Park, India

Atish says: "The idea was to shoot the transit at higher focal length with an interesting foreground, so we travelled from Delhi to the wind park where luckily we found suitable weather for shooting. It was one of our best astrophotography trips to date."

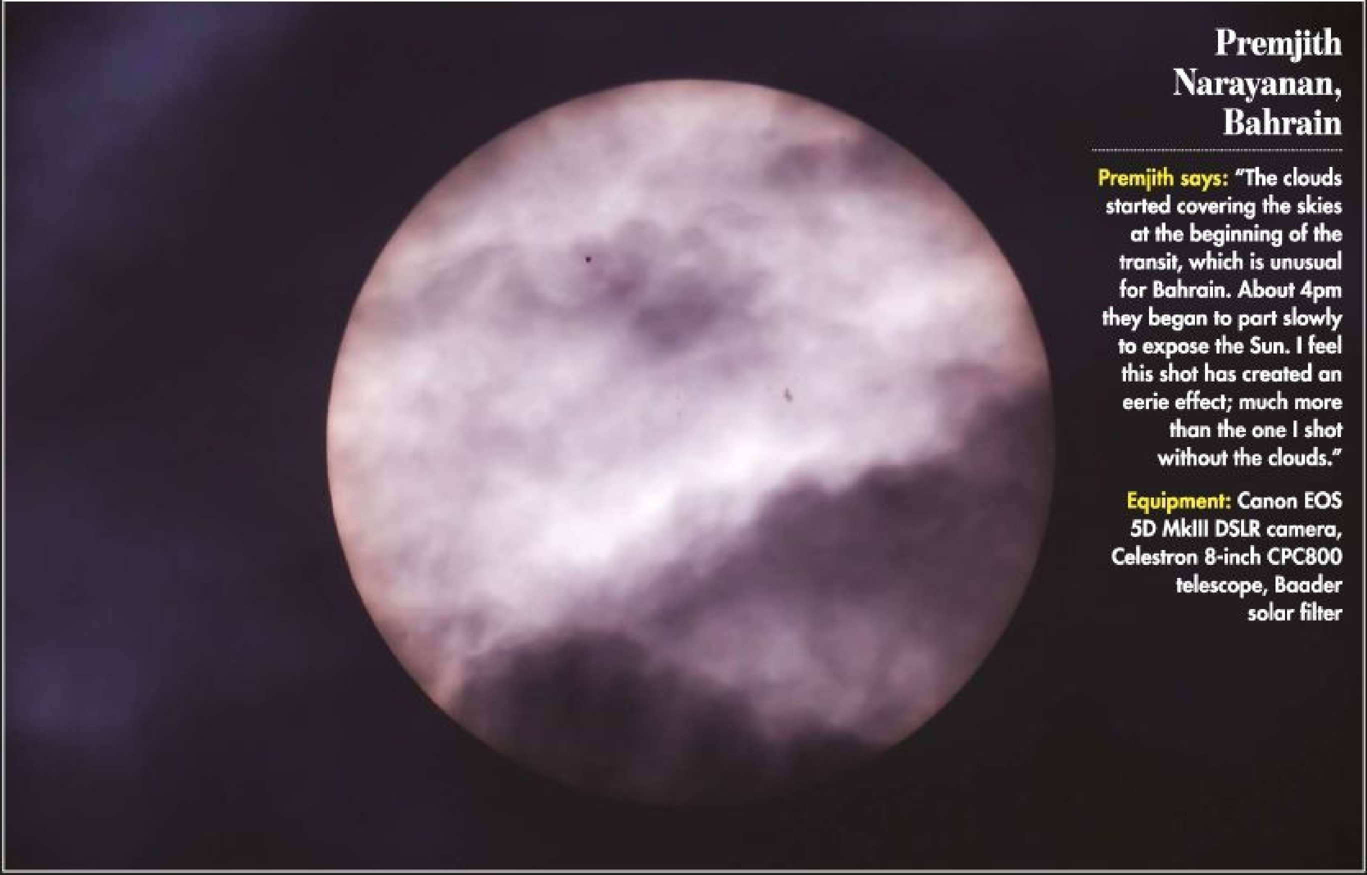
Equipment: Nikon Coolpix P900 digital camera.



◀ Paul Mason, Cannock

Paul says: "I took several shots and this one came out the best, considering cloud prevented a lot of imaging. I was amazed at the whole experience of watching and imaging a transit for the first time."

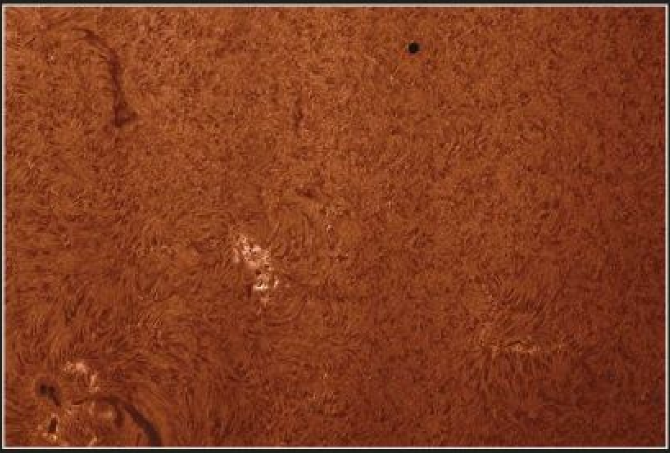
Equipment: Canon EOS 1100D DSLR, Meade LS 8-inch ACD LightSwitch telescope, white light filter.



Premjith Narayanan, Bahrain

Premjith says: "The clouds started covering the skies at the beginning of the transit, which is unusual for Bahrain. About 4pm they began to part slowly to expose the Sun. I feel this shot has created an eerie effect; much more than the one I shot without the clouds."

Equipment: Canon EOS 5D MkIII DSLR camera, Celestron 8-inch CPC800 telescope, Baader solar filter



▲ Pete Williamson, Shropshire

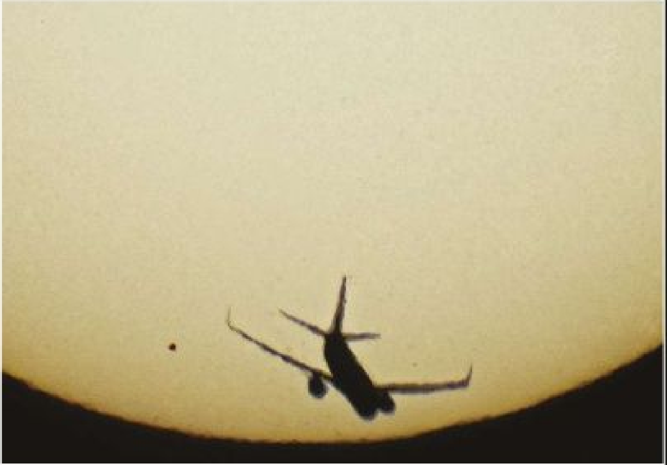
Pete says: "I headed off to Cardingmill Valley to set up alongside Shropshire AS for a public viewing of the transit. We were clouded out and sat drinking coffee until 3.30pm, when the cloud thinned. I grabbed this image as quick as I could in order to have a record of the day."

Equipment: ZWO ASI174MM camera, Coronado 3.5-inch SolarMax II telescope, APM 2.7x Barlow lens.

▼ Charles Thody, North Lincolnshire

Charles says: "I managed to capture this image of the transit of Mercury along with an airliner crossing the face of the Sun. It's one of those images I have had in my head for a long time and, as they say, the 'stars aligned' for once!"

Equipment: Canon EOS 40D DSLR camera, Sky-Watcher Equinox-80 apo refractor, Celestron Advanced AVX mount, Baader solar filter.



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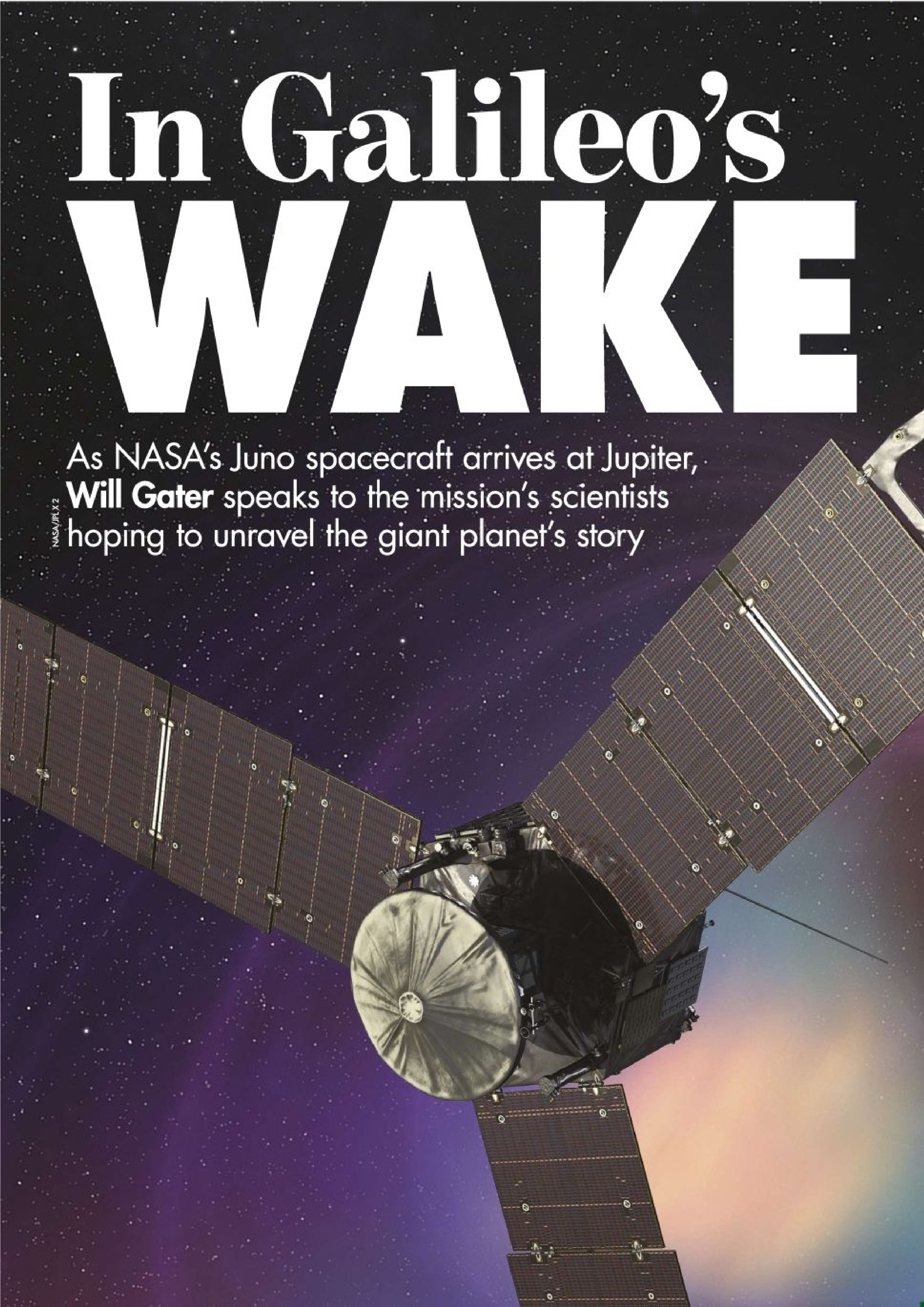
In Galileo's WAKE

As NASA's Juno spacecraft arrives at Jupiter, **Will Gater** speaks to the mission's scientists hoping to unravel the giant planet's story



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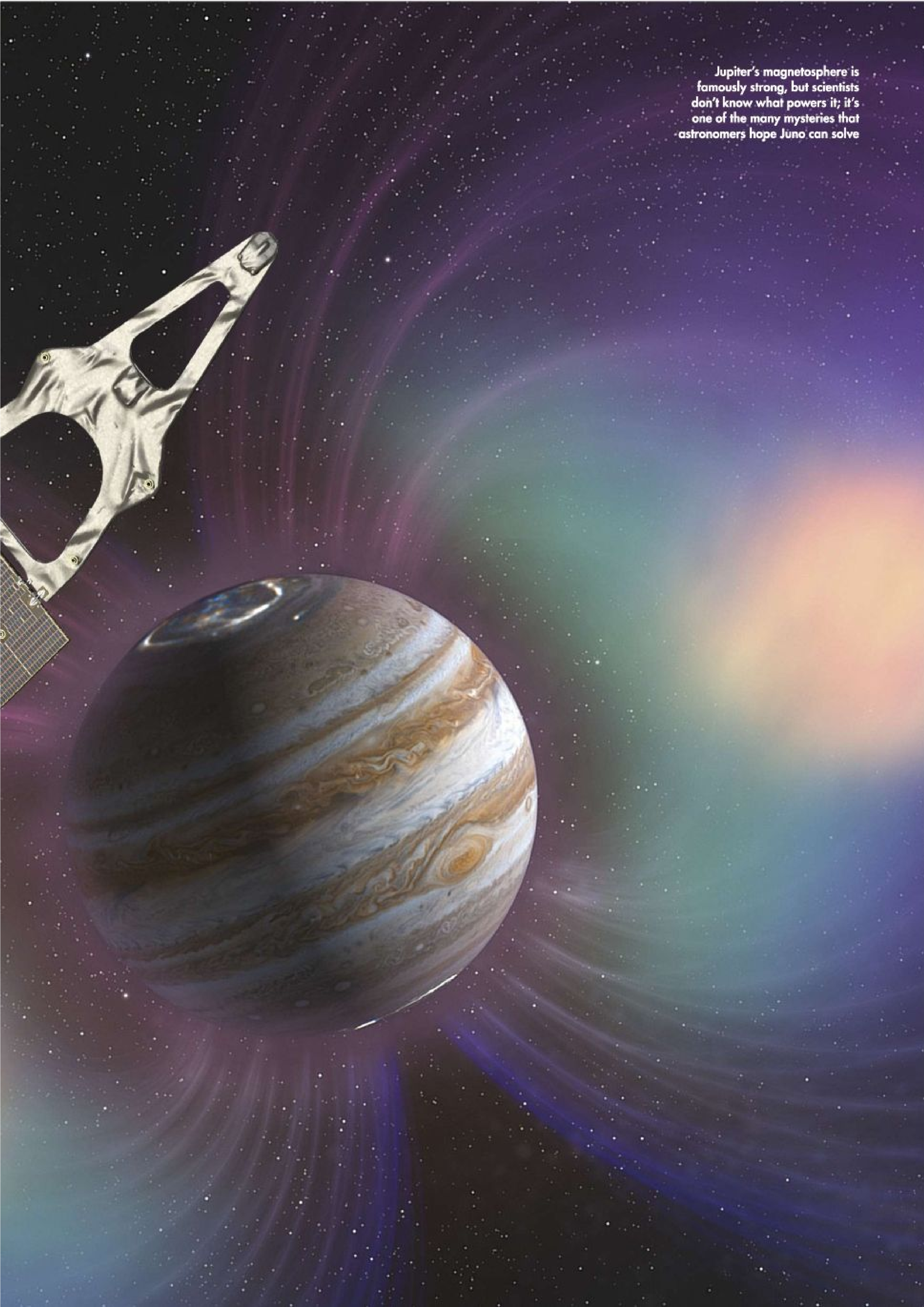


Jupiter's magnetosphere is famously strong, but scientists don't know what powers it; it's one of the many mysteries that astronomers hope Juno can solve

▲ Galileo was the first probe to orbit Jupiter, reaching the planet in 1995

▲ The roughly true colour of the Great Red Spot as seen by the Galileo probe in 1996

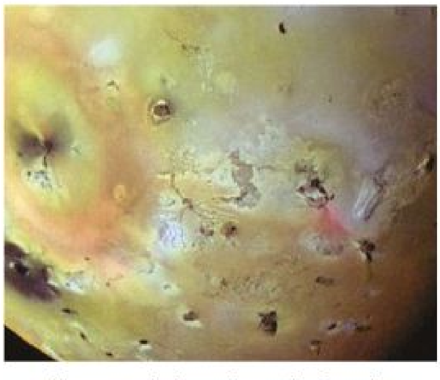
▲ Galileo glimpsed the Jovian belt/zone boundary up close when it visited the planet

On 4 July NASA's Juno probe will reach Jupiter, after a journey of four years and 11 months. Its orbital entry will mark the beginning of an exciting new phase of exploration of a world that's shrouded in both clouds and mystery. But if humanity's spacecraft could leave a celestial wake as they sail across the Solar System then Juno would today be riding the ripples left by another Earthly emissary to the Jovian system.

In 1989 NASA dispatched the Galileo spacecraft to Jupiter. After arriving there in 1995 it explored the gas giant for well over seven and a half years, returning stunning high-resolution images of the planet's atmosphere and large moons. Measurements by Galileo's instruments precipitated many thrilling discoveries – most famously they picked up tantalising signs that the moon Europa harboured a liquid water ocean under its thick, icy shell – and the orbiter was even able to send a smaller probe into Jupiter's cloud tops.

Though it has been more than 12 years since Galileo sent its last dispatch, its legacy is clear in the lives and careers of many of the researchers now involved in the Juno project. One of those is the mission's principal investigator, Dr Scott Bolton, who used Galileo to study Jupiter's vast magnetic field. As well as exploring the Jovian magnetosphere, one of the things Bolton became interested in while working on Galileo were the findings of the probe that had plummeted into the planet – findings that, as it happens, had a tremendous influence on the Juno mission he now leads.

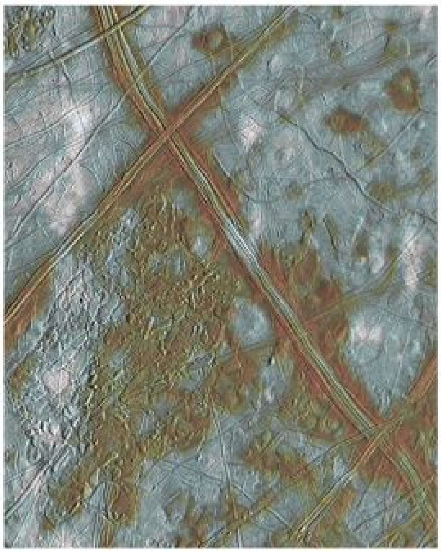
> "Galileo picked up tantalising signs that Europa harboured a liquid water ocean under its thick, icy shell"



▲ Galileo revealed Io to be violently volcanic; the red areas indicate regions of activity

As Galileo flew into Jupiter it made measurements of the planet's powerful radiation belts, buzzing with high-energy electrons. When it came to building Juno years later, designers were able to use that data to engineer a spacecraft that could withstand the harsh radiation levels detected in the vicinity of the giant planet. Not only that, but the information the Galileo probe returned has been crucial to the charting of the, relatively, safe course around Jupiter that Juno is now about to embark upon – a trajectory that avoids the radiation belts where the spacecraft might get zapped.

"There were only a couple of kinds of data sets that we could use to figure out the radiation belts around Jupiter," says Bolton. "One was [from] ground-based radio telescopes and the other is the Galileo probe data, which clearly showed that as the Galileo probe went in there was a gap where the radiation belts were intense and then the intensity dropped down like it is at the Earth – there's a gap between the radiation belts and the atmosphere. And in fact Juno's targeting that gap."



▲ The trailblazing probe showed us that icy moon Europa is scarred by stress fractures

The path of solar-powered Juno may have been revealed by Galileo, but it is not merely retracing its forebear's footsteps. The team hope that in returning to Jupiter they can gain vital new insights into the giant of our Solar System, and perhaps even answer some of the questions that Galileo left researchers asking.

One aspect of Jupiter the team are particularly keen to explore is the planet's enigmatic magnetic field, which intrigued Bolton and his colleagues all those years ago and remains a source of mystery today.

"Jupiter has a very strong magnetic field. But we do not know much about the magnetic dynamo generating the field deep inside the planet," says Juno scientist Prof Fran

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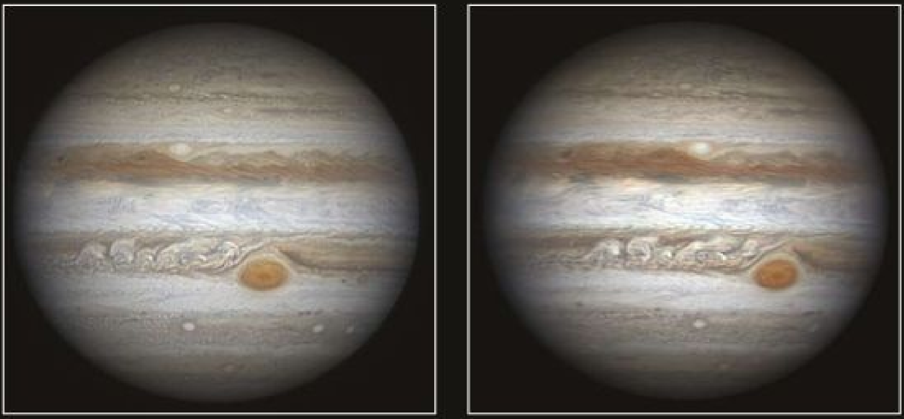
JUNO'S EYES ON THE GROUND

How amateur astronomers can help decide the mission's photographic targets

Prior to the spacecraft reaching the planet, the Juno team enlisted the help of a global ensemble of amateur imagers to assist them in identifying Jovian atmospheric features to target with one of their cameras.

The camera, JunoCam, will capture colour views of Jupiter at the visible wavelengths of light that you and I can see. "JunoCam is actually a very different camera than we've flown before," says Dr Candice Hansen, who is in charge of the project. "Rather than including a telescope with a long focal length, like Voyager, Cassini, and Galileo, we opted for a very wide field of view. We made that choice in order to be able to image the entire polar region of Jupiter just one hour away from closest approach."

One of the things that Hansen and her colleagues have been asking amateurs to do is upload their latest high-resolution pictures of the Jovian disc to www.missionjuno.swri.edu/junocam. "Because Jupiter has such a dynamic atmosphere, up-to-date images are needed for planning," she says. "We showcase [the amateurs'] images and turn them into a cylindrical map every two weeks."

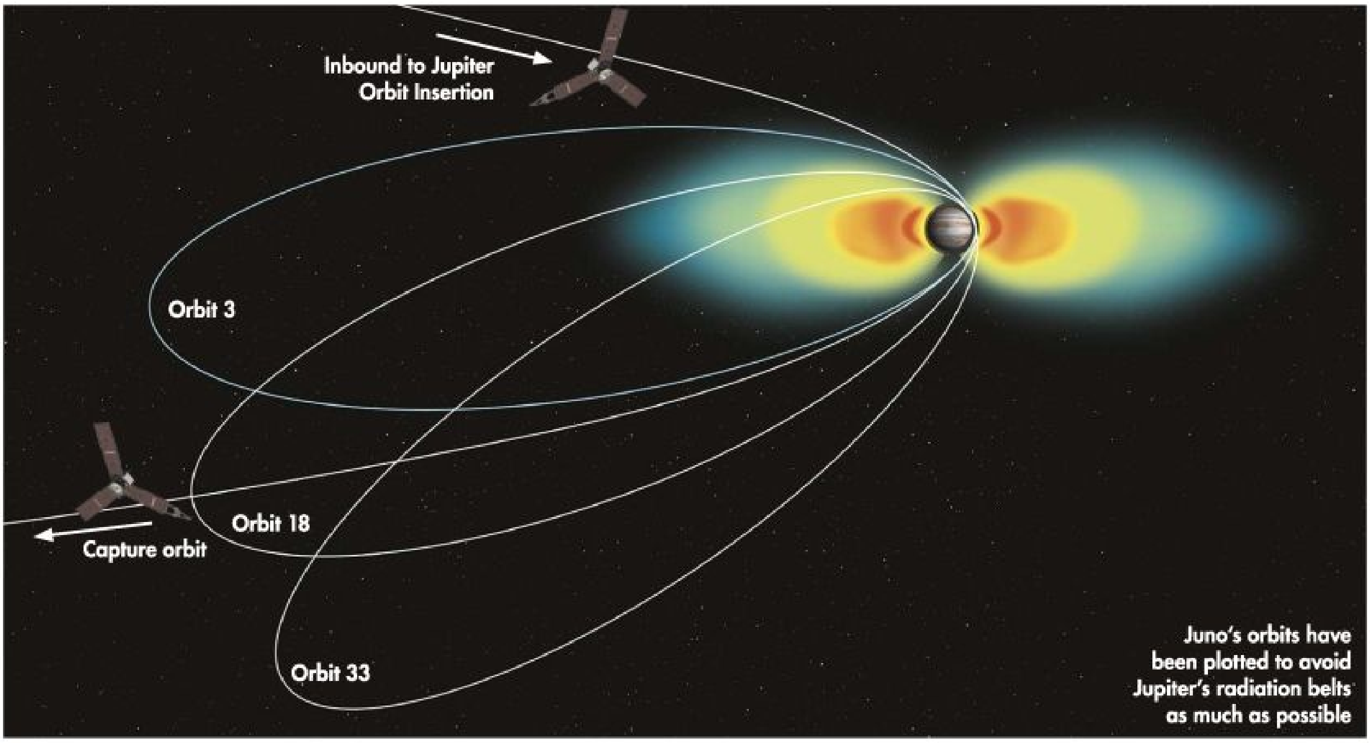


▲ By comparing images taken from different Earth locations at different times, Juno scientists hope to characterise Jupiter's atmosphere in terms of storm activity, wind intensity and more

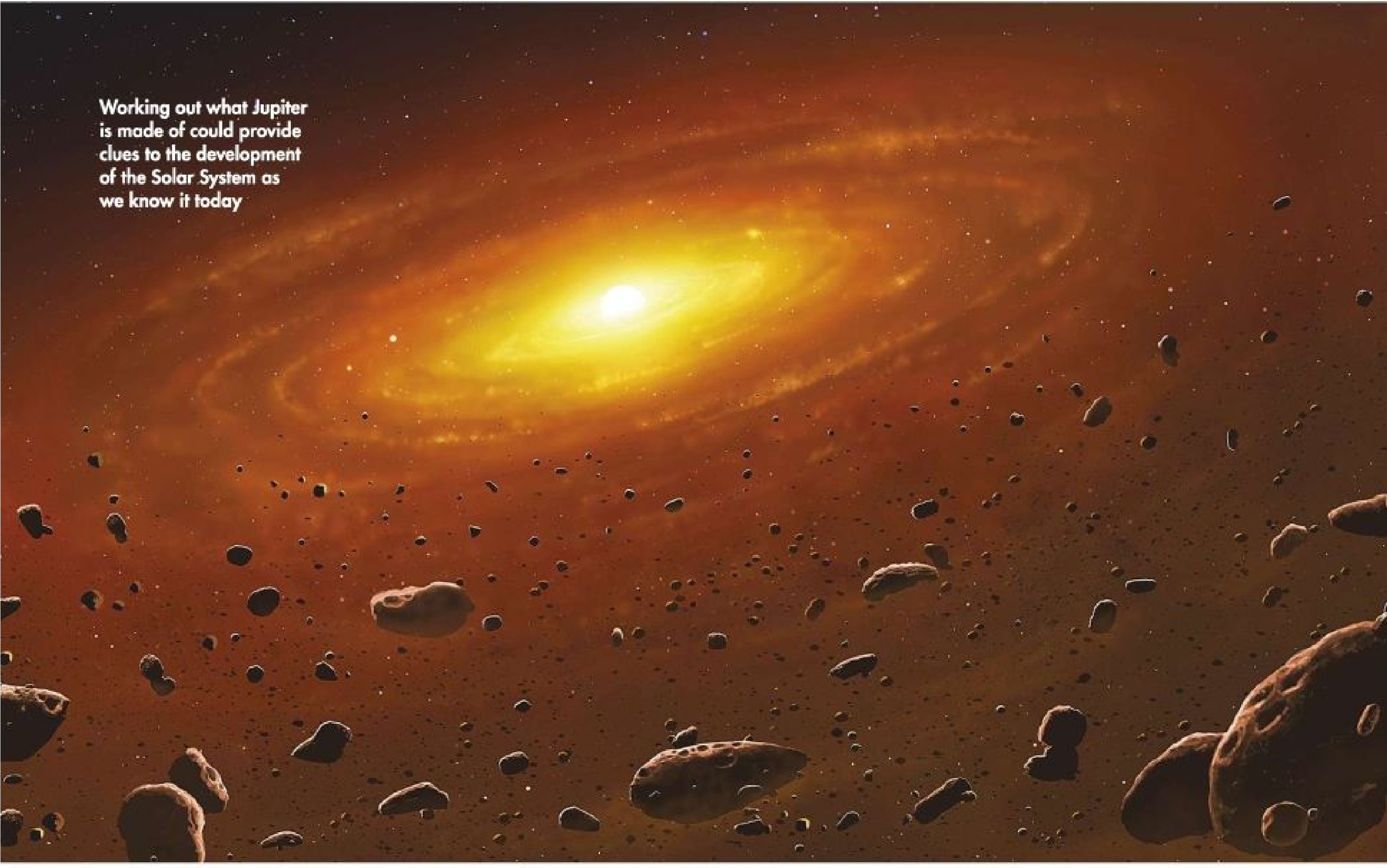
From this map, members of the public can then suggest and discuss potentially interesting atmospheric features that JunoCam might want to have a look at. "We are inviting the public to be part of the discussion, just as a science team would normally do in a conference room or on a telecon," says Hansen. "Then, when it is time to actually build the camera commands, we will know what longitude we will be crossing from the north to the south, and which points of interest will be accessible. We will get a general discussion going on the strategy for that particular pass and ask the public to vote on what we should image."

Bagenal. By taking readings as the spacecraft flies around Jupiter, Juno's sensitive magnetometer should be able to provide some clues as to precisely how the planet's magnetic field is made.

"What's special about the magnetometer is that it will be able to measure a very wide range of magnetic fields – from the very strong fields up close to the weaker field in the outer regions of the magnetosphere," says Bagenal. It's not the only instrument on Juno that will be trying to uncover the nature of Jupiter's hidden heart, however. The spacecraft is also equipped with an instrument that will make detailed measurements of the gravity field around the planet. This should tell scientists whether Jupiter has a core made of rock, ice and heavy elements, as some theories predict it does. ▸



Juno's orbits have been plotted to avoid Jupiter's radiation belts as much as possible



Working out what Jupiter is made of could provide clues to the development of the Solar System as we know it today

► By combining the information gleaned about the gravity and magnetic fields with studies of the planet's composition made by some of Juno's other instruments, the team hope to create a picture of how Jupiter's interior is arranged and which models describe that structure best.

"The magnetic field helps us because the origin of the magnetic field we think comes from where the hydrogen (the gas that Jupiter is predominantly made of) becomes metallic – it gets pressurised and becomes like a metal and behaves like a fluid," says Bolton. "So somehow we have to build up an entire interior structure of Jupiter that eventually leads us to the question of whether Jupiter has a core. But how it's structured in the middle (where it's thought the magnetic field originates) helps us constrain how the structure works throughout its interior."

Understanding Jupiter's make-up and what's going on inside it should shed considerable light on the planet's past. But that isn't the only reason that planetary scientists are so interested in what hides deep below the gas giant's cloud tops; that information can also give us a glimpse of the wider genesis of the solar neighbourhood.

"Jupiter has this prehistoric history of our Solar System in it because it's so massive and big that its gravity field was able to hold on to the material that it was formed with," says Bolton. "It allows us to go back in history by seeing how it's made and what it's made out of to sort of construct the history of what went on early in the Solar System."

Analysing Jupiter's chemical composition in detail, which Juno will do while in orbit, will be key to unravelling this complex history. "One of the things that the Galileo probe showed us is that Jupiter is enriched in what cosmologists call 'heavy elements'. It's almost the same as the Sun as far as hydrogen and helium goes, but it has a larger percentage of carbon, nitrogen, sulphur, all the heavy elements, everything on the chemistry table beyond helium," explains Bolton. "We don't understand how that happened. We know it's important to learn how that happened because the stuff that Jupiter is enriched with is what we are made out of. So it connects right back to what was going on. How did the planets get these extra heavy elements that enabled the Earth and other terrestrial planets to form? These are the elements that life, even, came out of."

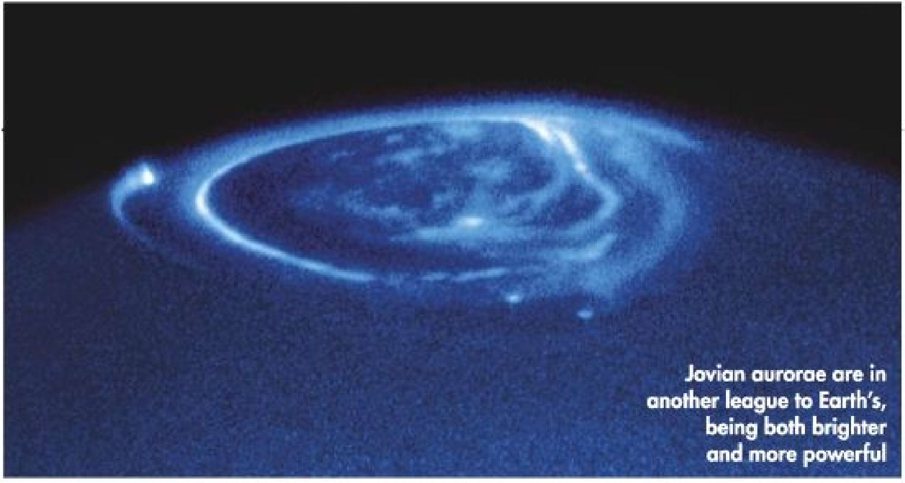
The Juno team won't have long to wait to begin investigating these questions and more. After firing its rocket to slow down, the spacecraft will be captured by Jupiter's gravity early this month. From then on it'll follow an elliptical orbit around the planet. Before all this, though, Juno has a thrilling dive low over the planet, at astonishing speeds, to look forward to.

"When we come in, when we drop down, our closest approach to Jupiter is only 5,000km above the cloud tops," says Bolton. "So we are really, really close. And we're screaming, we're moving at about 250,000km/h, which will actually set the record, that'll be the fastest human-made object in history."

Once it's looping the gas giant, Juno's orbit will take it

▲ The Cassini spacecraft's best views of Jupiter's polar regions from its flyby in 2000

© MARK GARLICK/ALAMY STOCK PHOTO, NASA/JPL/SPACE SCIENCE INSTITUTE X 2, ISTOCK, NASA/ESA & JOHN T. CLARKE (UNIV. OF MICHIGAN), ESA/ATG MEDIALAB, NASA/JPL-CALTECH



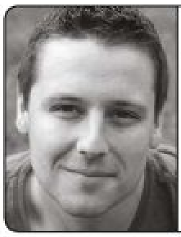
Jovian aurorae are in another league to Earth's, being both brighter and more powerful

flying right over Jupiter's poles; this'll provide its cameras and instruments with an opportunity to study the Jovian aurorae, which are far brighter and more powerful than Earth's own. "If you or I were on the spacecraft and we floated above Jupiter we would definitely see that aurora. It would be [a] spectacular view every time we could look at the night side," he says.

Just like many other modern space missions, such as Cassini, we can expect Juno to return a slew of captivating images. These include pictures returned by the mission's JunoCam project, which has seen amateur astronomers involved in monitoring and identifying potential atmospheric features to photograph.

"You'll see some of the most spectacular images you've ever seen," enthuses Bolton. Unlike Cassini or the Mars Exploration Rovers, however, Juno's mission isn't expected to go on for years and years. "We'll stay about a year and a half once we get into our final orbit, which doesn't happen until November," he adds. "We may get some small extensions, but not like Cassini because we're in a very intense radiation field and we know that at the end of the mission we're getting a lot of radiation. So we don't expect to be able to last for four more years."

That shouldn't matter though. Because, if all goes to plan, by the time it comes to Juno signing off it'll have already made some sizeable ripples of its own. Ⓢ

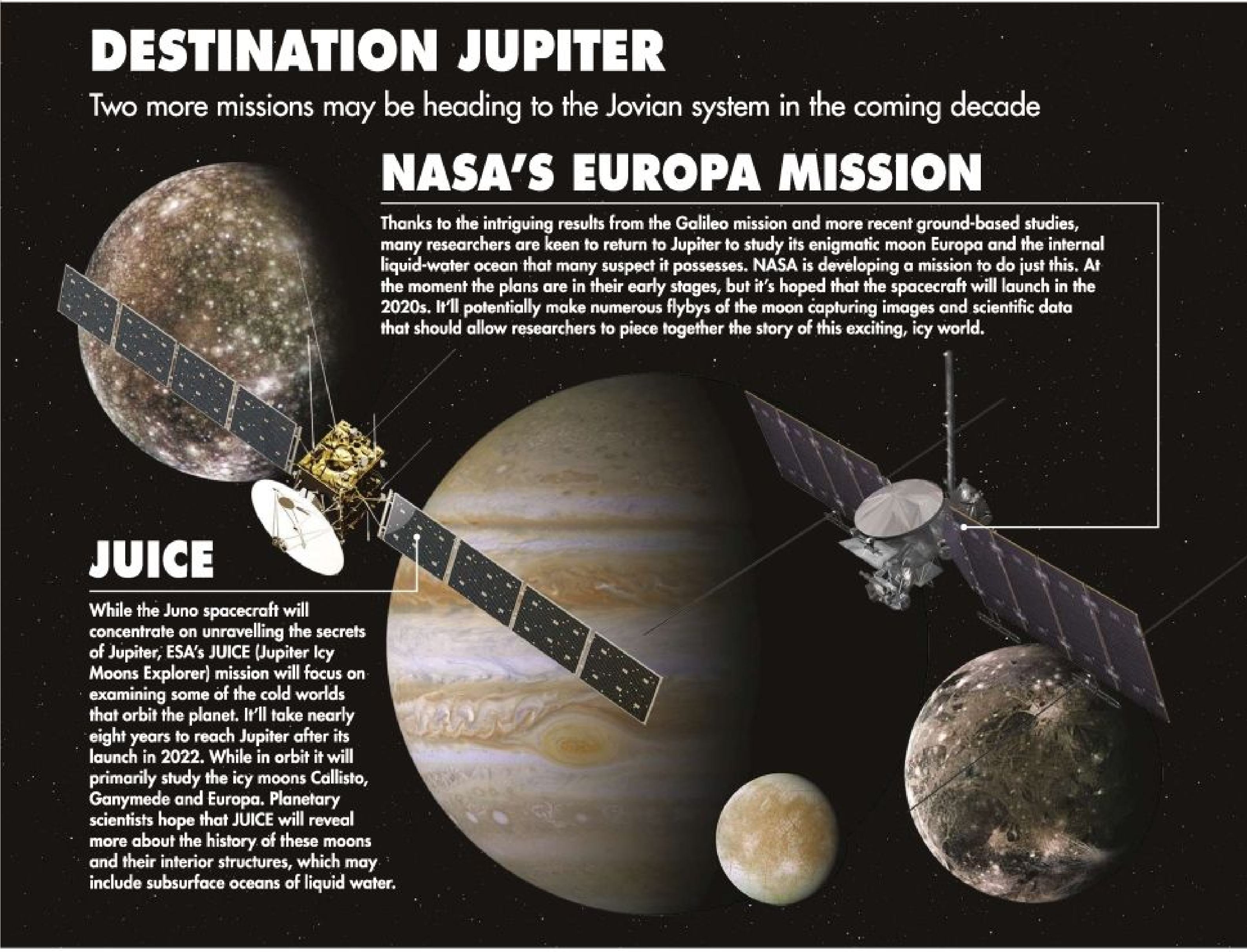


ABOUT THE WRITER

Will Gater is an astronomy journalist, author and astrophotographer. Follow him on Twitter: @willgater

DESTINATION JUPITER

Two more missions may be heading to the Jovian system in the coming decade

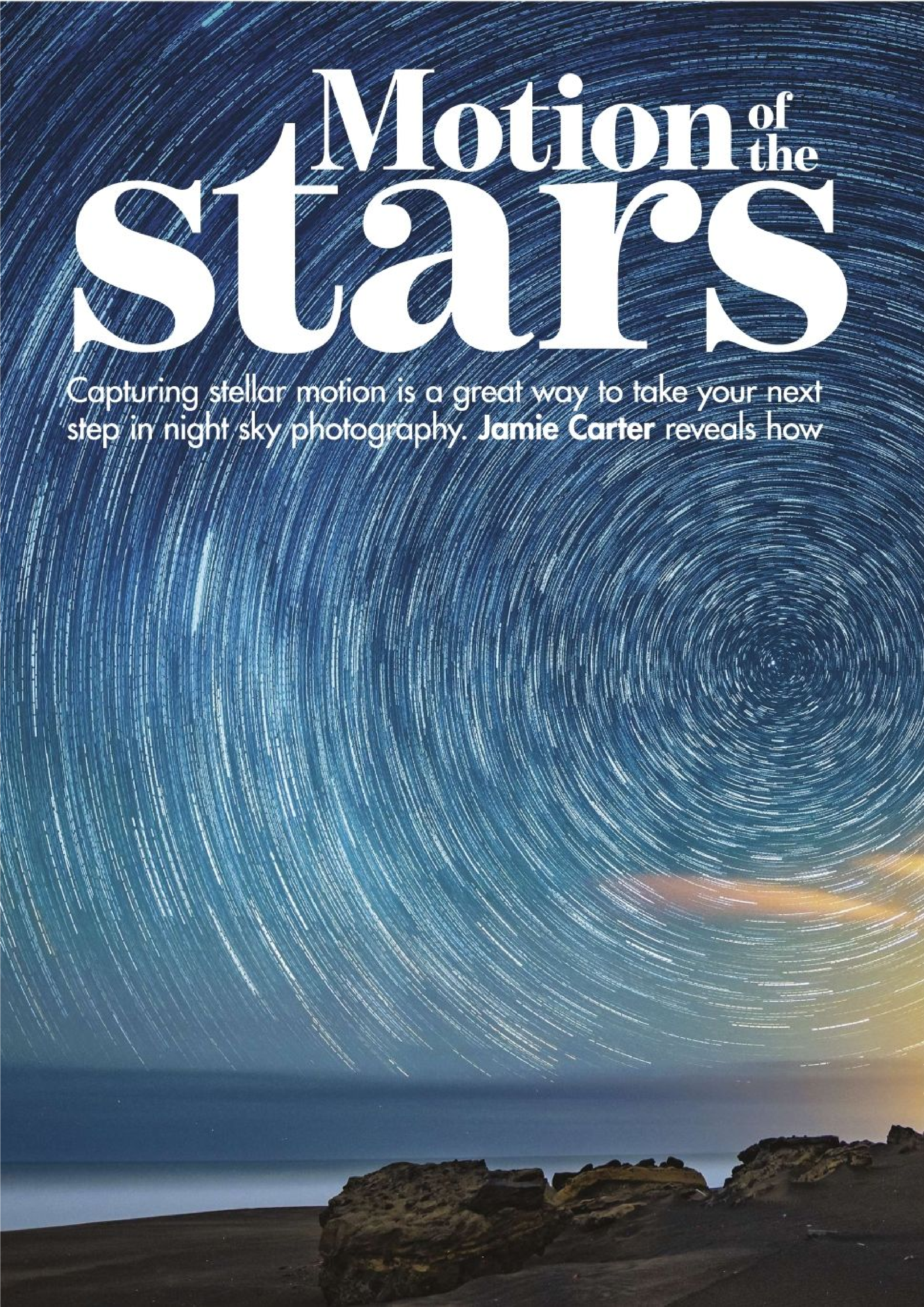


NASA'S EUROPA MISSION

Thanks to the intriguing results from the Galileo mission and more recent ground-based studies, many researchers are keen to return to Jupiter to study its enigmatic moon Europa and the internal liquid-water ocean that many suspect it possesses. NASA is developing a mission to do just this. At the moment the plans are in their early stages, but it's hoped that the spacecraft will launch in the 2020s. It'll potentially make numerous flybys of the moon capturing images and scientific data that should allow researchers to piece together the story of this exciting, icy world.

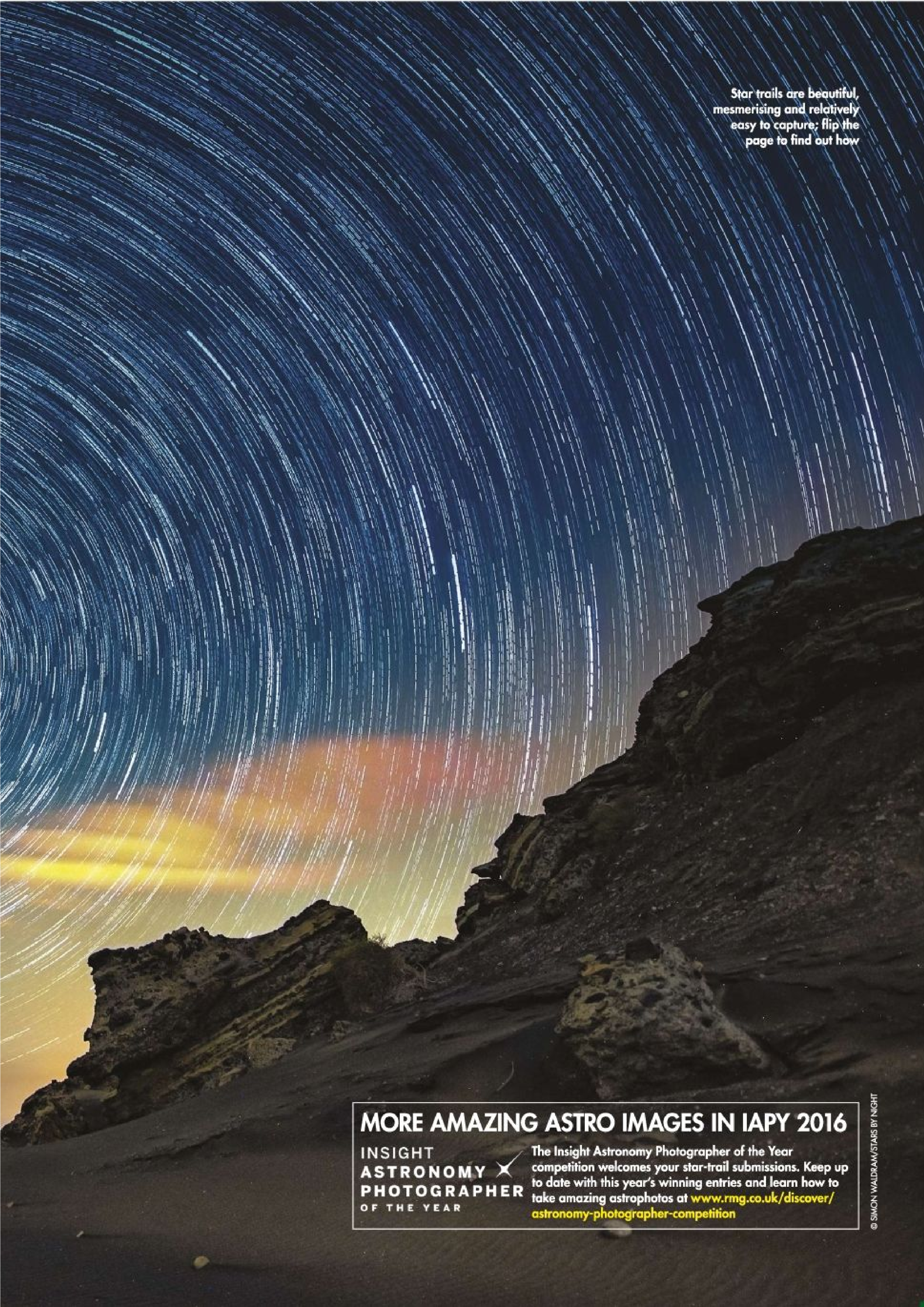
JUICE

While the Juno spacecraft will concentrate on unravelling the secrets of Jupiter, ESA's JUICE (Jupiter Icy Moons Explorer) mission will focus on examining some of the cold worlds that orbit the planet. It'll take nearly eight years to reach Jupiter after its launch in 2022. While in orbit it will primarily study the icy moons Callisto, Ganymede and Europa. Planetary scientists hope that JUICE will reveal more about the history of these moons and their interior structures, which may include subsurface oceans of liquid water.



Motion of the stars

Capturing stellar motion is a great way to take your next step in night sky photography. **Jamie Carter** reveals how



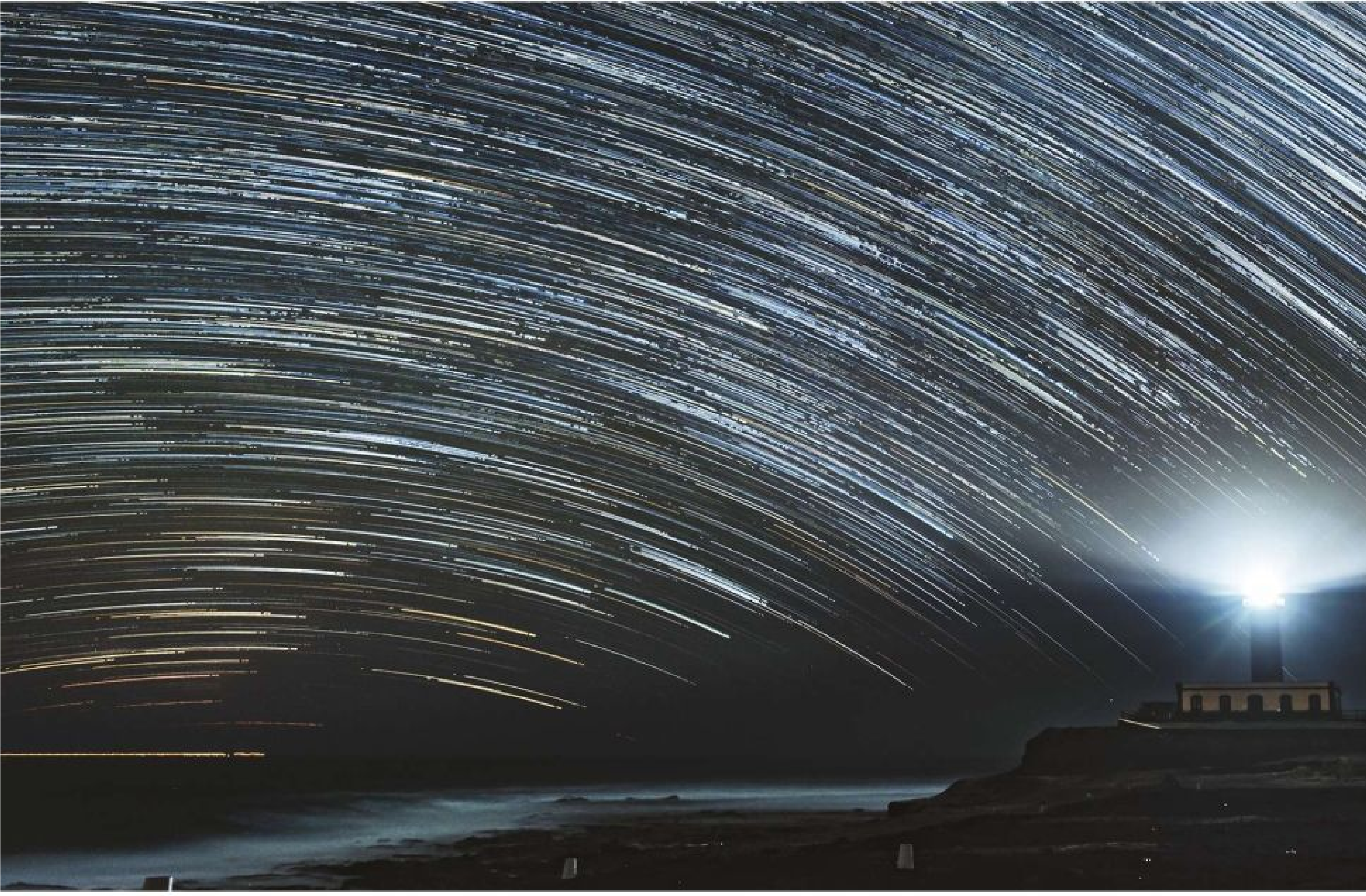
Star trails are beautiful, mesmerising and relatively easy to capture; flip the page to find out how

MORE AMAZING ASTRO IMAGES IN IAPY 2016

INSIGHT
ASTRONOMY
PHOTOGRAPHER
OF THE YEAR

The Insight Astronomy Photographer of the Year competition welcomes your star-trail submissions. Keep up to date with this year's winning entries and learn how to take amazing astrophotos at www.rmg.co.uk/discover/astronomy-photographer-competition

© SIMON WALDRAM/STARS BY NIGHT

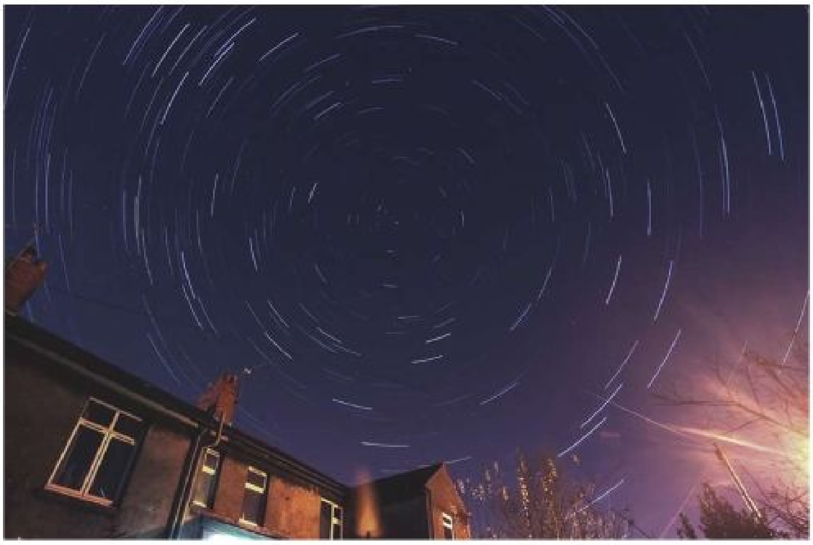


▲ **Though Polaris is a good marker, you don't have to include it; this image points south, creating a 'falling stars' effect**

A good star trail can be mesmerising, the circular pattern offering up a new perspective on the rhythms of the night sky. Although some will gaze at such photos with awe, producing an image that shows the apparent movement of the night sky over an hour or so is a relatively simple technique, and is as much about planning and commitment as it is about skill. And that is exactly what we are going to discuss here.

As with any night-sky photography, too much light will wash out the stars. To maximise the number of stars in the final image, you need to take your astrophoto from somewhere dark, away from artificial light. However, this doesn't mean you can't create a star trail from a back garden in the middle of the city. You can, and the finished image can still be impressive, but it won't have as many stars as one taken in the countryside.

If you want to capture the classic 'rotating sky' effect, remember that in the northern hemisphere you will have to shoot north at Polaris, and in the southern hemisphere, point south at the Southern Cross (from March to September) or near bright stars Achernar or Canopus (from October to February). Take a compass with you in daylight and you can plan your shot before it even gets dark.



▼ **Star trail shots can be captured from urban sites, even with artificial sources of light nearby**

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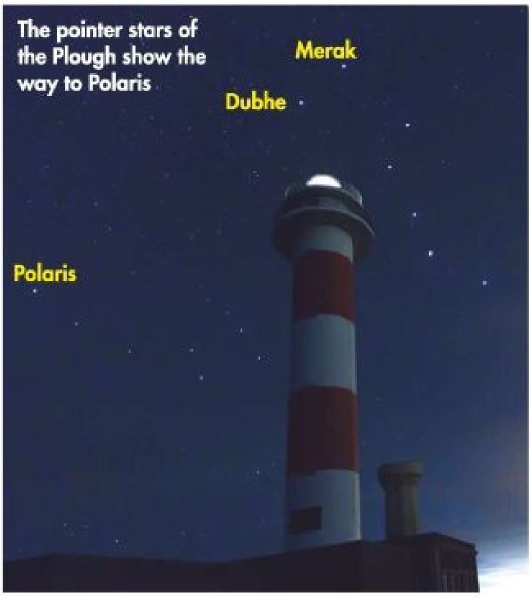
Just as important as avoiding light pollution is the position of the Moon. A lot of astro imagers have three weeks off every month and only venture outside during the week of a new Moon, when the slim lunar crescent rises late and sets early. However, while a bright Moon does wash out a lot of stars, it's perfectly possible to capture good-looking star trails even near the full phase. Moonlight causes a bluish night sky, but it can illuminate the foreground nicely – it all depends on your shot.

First find Polaris

If you're going to shoot star trails from the northern hemisphere, you need to know exactly where to find Polaris, the pole star. Earth's axis points almost directly at it, so it sits permanently above the north pole in the northern sky; the rest of the stars appear to revolve around it as Earth rotates.

Locating Polaris is easy if you star-hop from the pointer stars in the Plough asterism, Merak and Dubhe. These are the two stars on the outside of the Plough's bowl. Imagine a line from Merak to Dubhe, and carry on for about five times the



The pointer stars of the Plough show the way to Polaris

distance between those two stars. Although Polaris is only the 48th brightest star, it is fairly prominent in its surroundings. It appears higher in the sky the farther north you travel (and vice versa): from the UK, it's between 50° and 59° altitude.

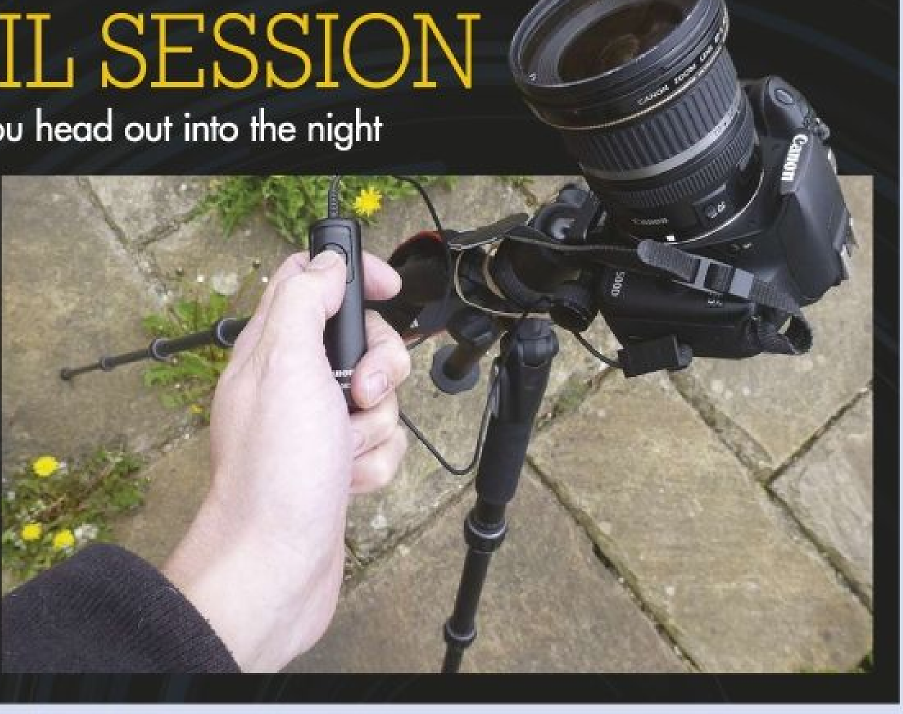
Exactly where Polaris sits in the night sky from where you are on the planet can dramatically alter your composition choices. For instance, in the UK it's likely that Polaris will sit way above any building you want to include unless you get in close, and it can be tricky getting much foreground in. However, you must get something in the foreground since the presence of star trails alone will not produce an eye-catching photograph. The 'rule of thirds' applies; imagine a noughts and crosses board on your viewfinder and put something on one or more of the four corners of the middle square. Landscapes with a lot of depth work well with star trails, but so do derelict or grand buildings, mountains, striking rock formations and unusual urban landscapes.

There are two ways to produce a star trail; the first is to open the shutter on your camera for a ►

PACKING FOR A STAR TRAIL SESSION

The essential kit to take as you head out into the night

A planetarium app is useful if you're not confident in finding Polaris (or the celestial south pole if you're near to or beyond the equator). For the photograph you'll need a DSLR (a full frame model is best, but a crop-sensor works fine) on a tripod, ideally with a wide-angle lens. A torch is also handy for 'light painting', though the old fashioned incandescent bulbs are better than LED models, which create a very cool light. To avoid any camera shake, which can easily ruin a star trail, use a remote shutter release cable, which attaches to the side of your camera. A remotely operated intervalometer will make your camera completely autonomous, which makes our final accessories essential: a blanket, a chair and a like-minded friend to keep you company.



A good star trail image needs to be composed with the same care as a landscape photo

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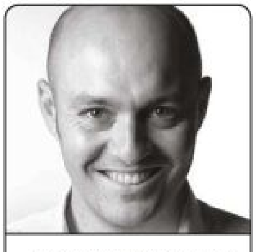
▸ long period, and the second is to take multiple short exposures and stack them into one image. The 'old' way of opening the shutter for over an hour is now best avoided. "It was fine when using film cameras, but digital cameras' sensors just get too hot, so it's best to take lots of 30-second exposures, about 15 seconds apart, and stack them together," says Simon Waldram, star trail tutor for Stars By Night in Fuerteventura. However, you can also choose between shooting about 10-20 three-minute exposures or 50-100 exposures of about 30 seconds. The latter is easier.

Time to start shooting

If you're shooting multiple 30-second images to stack later – which you should if you're using a digital camera – then the settings are the same as for any night-sky shot; use a tripod, a wide-angle lens on the lowest aperture setting possible, and shoot at around ISO 800 to avoid too much noise.

"Always shoot in RAW format," says Simon. "That way you can use Photoshop to reduce the noise and any light pollution." Set the lens to manual focus, then either pre-focus it to infinity (some cameras have a ∞ symbol on the lens), or shine a torch on something 20m or so away and focus on it using autofocus (then switch back to manual). Tungsten white balance can help reduce the effects of any light pollution.

You can experiment with light, too; once you have finished capturing your star trail images, consider taking a couple more using one-second bursts of torchlight on your subject to create different lighting effects. You can then either use them or discard them when you come to stack your images, thus creating a few different versions of your final shot. Ⓢ



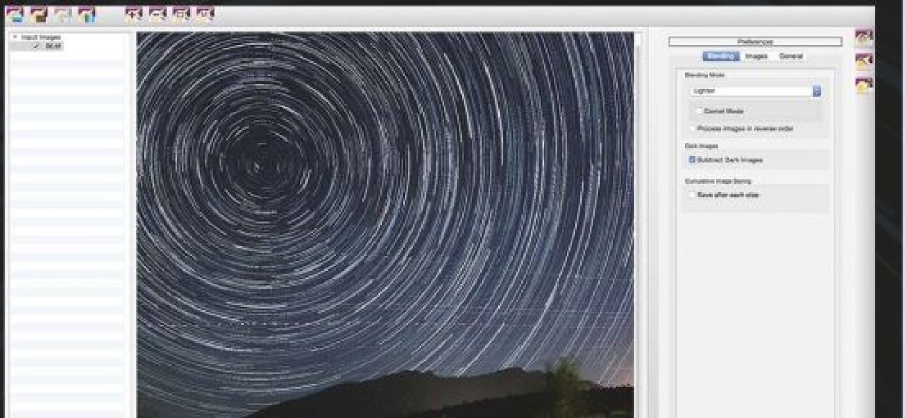
ABOUT THE WRITER

Jamie Carter is the author of *A Stargazing Program for Beginners: A Pocket Field Guide,* which includes many astrophotography projects for beginners.

STAR TRAIL SOFTWARE

Two essential programs for top trail images

Few of us want to spend hours editing photos, but it's crucial for producing a good, clean image. Photographers all have their favourite photo-editing suite, but it's hard to beat Adobe Photoshop (paid; www.adobe.com/uk/products/photoshop) for night-sky images. It's possible to batch-process the 80-200 images you might have from a star trail shoot relatively quickly, though a computer with 16GB RAM helps enormously, so an average laptop will be slow. Another capable software option is StarStaX (free; www.markus-enzweiler.de/software/software.html). This is a small application that lets you drag in multiple images that it then merges into a single star-trail image before your very eyes.



Blending Mode: Lighten
☐ Comet Mode
☐ Process images in reverse order
Dark Images: ☑ Subtract Dark Images
Cumulative Image Saving: ☐ Save after each step

STEP-BY-STEP: SHOOTING A STAR TRAIL

How to choose a fascinating foreground, take your shots and process them properly

STEP 1 IDENTIFY A SUBJECT

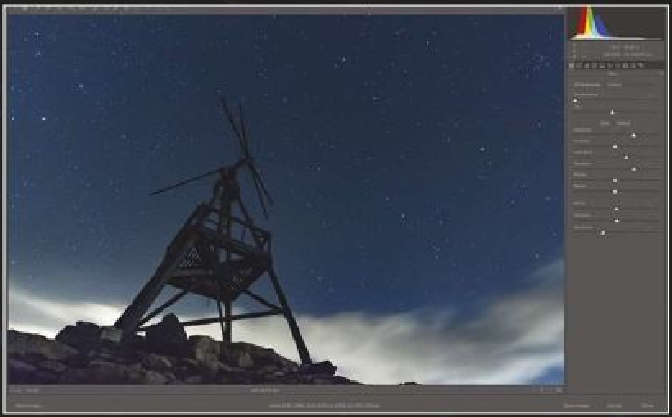
Think about composition. Look around for a subject in the foreground that will help you to give the final image an unusual point of interest, and photograph it from various positions both near and far. Identify where Polaris is and decide where you want it in your image. If it's cloudy, wait until conditions improve.

STEP 2 TAKE SOME TEST SHOTS

Zoom in to check that your focus is sharp. Don't rush this. Decide how many shots you're going to take and begin shooting, leaving 15 seconds between each shot for the sensor to cool down. If you wait less than 15 seconds you will be left with hot pixels and noise. Any longer and you will start to see gaps in the trail lines.

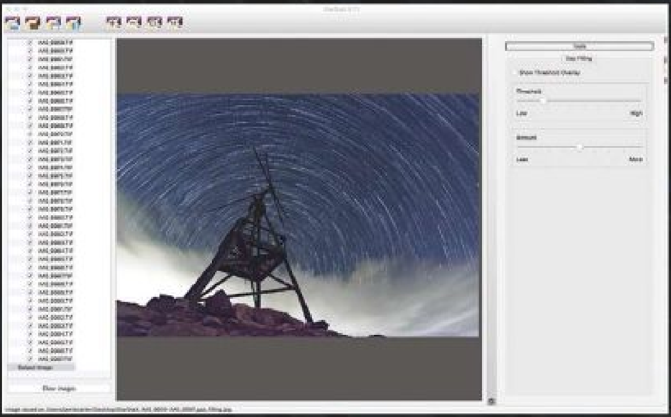
STEP 3 BEGIN SHOOTING

Insert a fresh battery. If you're using an intervalometer to take the images, you can sit back and relax while the camera captures the images. If you're pressing the shutter release button manually for each shot, don't touch or kick the tripod while doing so; the slightest nudge will ruin a trail halfway through.



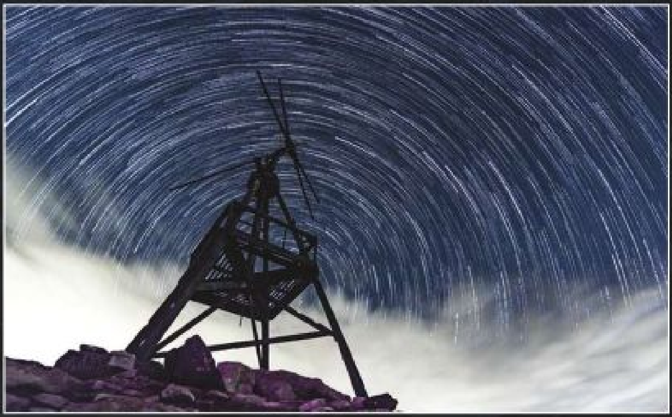
STEP 4 BATCH-PROCESS YOUR IMAGES

Photoshop lets you process one single image then apply all your changes to every image, a technique called batch processing. This is best done on a desktop computer with at least 16GB RAM. Cool the colour temperature, increase the exposure and sharpness, use the luminance slider to reduce noise and experiment with the de-haze tool.



STEP 5 LAYER THE IMAGES

Drag the processed RAW images into StarStaX and watch as a trail image is produced; the process takes about five minutes, with options to create 'comet tails'. If you have aircraft tail-lights in some shots, identify which frames they are and delete them before re-doing the StarStaX step and checking the box marked 'gap-filling'.



STEP 6 THE FINISHED IMAGE

When StarStaX has finished layering the photos, you are done! If you timed your shots correctly, your trails should be free of gaps. All that is left is to save the finished image. Although StarStaX can only generate a compressed Jpeg for the final result, it is high resolution – and a great result for a few hours' work.

DETECTING DISASTER

ASTEROID DAY
30 JUNE

Asteroids are a real and continued threat to life on Earth. **Elizabeth Pearson** investigates what's being done to discover them before it's too late

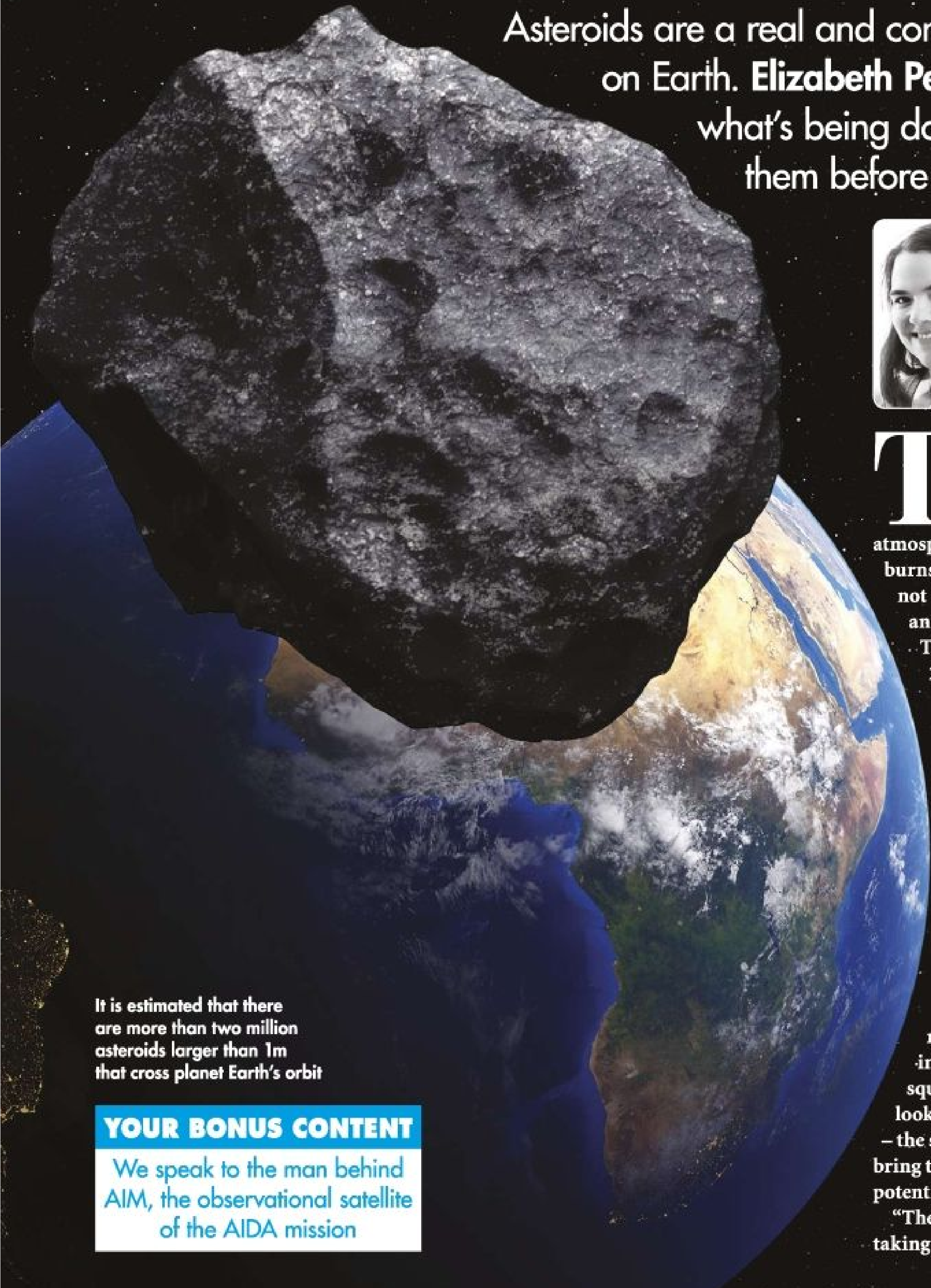
ABOUT THE WRITER
Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University.

The world is being bombarded from space. Every day, hundreds of tonnes of space rock and dust hit our planet's atmosphere – most of which fortunately burns up in the atmosphere. But that's not always the case. On 30 June 1908, an asteroid came down near the Tunguska River in Siberia, flattening 2,000 square km of woodland. If a similar event were to happen today over a major city, the casualty count would be in the millions.

In 1908, no one could have seen the meteor coming, but with today's technology we have no such excuse. On the anniversary of the Tunguska event, scientists gather together for Asteroid Day, sending out a rallying cry to watch for these potentially fatal space rocks.

Already there are several NASA-run surveys scanning for potential impactors. They scan up to 6,000 square degrees of sky per night, looking for near-Earth objects (NEOs) – the space rocks with orbits that will bring them close to our planet and could potentially hit us.

"These surveys discover asteroids by taking a series of three or four images of



It is estimated that there are more than two million asteroids larger than 1m that cross planet Earth's orbit

YOUR BONUS CONTENT
We speak to the man behind AIM, the observational satellite of the AIDA mission

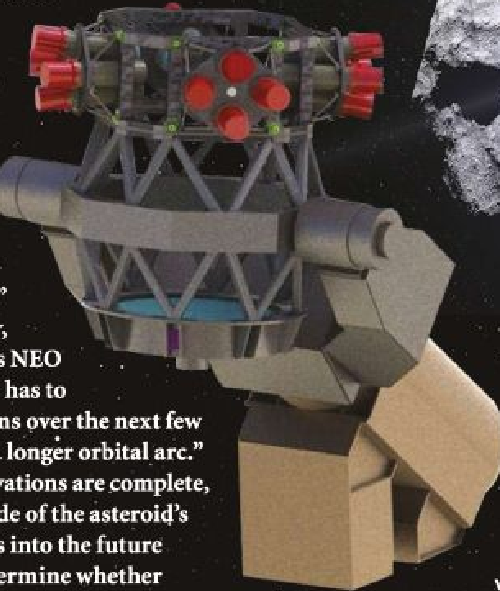
the same area of sky over an hour," says Paul Chodas, manager of the JPL centre for NEO studies. "Then a computer program searches for pinpoints of light that are moving across the star background in that time."

Word is then sent around a network of amateur and professional astronomers who will train their telescopes on the object to try and learn as much as they can about its path before it disappears from view.

"If a survey telescope discovers an asteroid, its position is only very poorly known," says Detlef Koschny, co-manager of ESA's NEO segment. "Someone has to perform observations over the next few days so that we get a longer orbital arc."

Once these observations are complete, forecasts can be made of the asteroid's orbit up to 100 years into the future – allowing us to determine whether rock threatens Earth.

AIDA is comprised of two satellites; an impactor to slow down a space rock and another to determine its success



◂ ESA's 'Fly-eye telescope' will use 16 lenses to deliver its huge field of view

▸ It is hoped that these new missions will help avert a repeat of the Tunguska event

But we need to do better

Yet despite all these surveys, NEOs are still slipping through – the most famous of recent memory being the 20m Chelyabinsk meteor of 15 February 2013. The resulting shockwave broke windows and shook buildings, injuring 1,500 people. And it had come as a complete surprise.

"Of the NEOs between 20m and 40m we know less than one per cent," says Koschny. "There's a lot left out there in that size range. That's why we need to scan the whole sky every night, only then will we detect the small objects."

To accomplish this task, ESA has begun constructing a new type of survey scope, currently named the 'fly-eye telescope'. It will have a massive 45 square degree field of view and will be devoted to ensuring that small, dim NEOs don't slip through the net. It is due to start operating in 2018.

Asteroid detection rates are also improving thanks to the NASA's WISE satellite. As well as being able to image at any time – regardless of whether it is a clear night on Earth – being beyond our planet's atmosphere allows researchers to search in the infrared. And, as Chodas points out, "Asteroids are brighter than the background stars in the infrared, so they stand out better." WISE has been searching the sky for NEOs in the infrared since 2013. As of April 2016 it had discovered 72 new objects, and was observing hundreds more.

With new surveys and improved technology, the rate of detection has been rising steadily. Should an asteroid pose a serious threat to us, it is increasingly likely that we would detect it and assess its danger long in advance. The question then is: what would we do next?

For smaller asteroids, just knowing that they are coming would be enough to avoid most harm. These rocks mostly break up in the atmosphere and any damage from the resulting shockwave can be easily avoided.

"All you would need to do is contact the media and tell people not to stand near windows in case they shatter," says Koschny. "For objects larger than 100m, though, you would want to evacuate."

Finalising evacuation plans could be problematic, however. It is possible to estimate where an asteroid might land, but only within hundreds of kilometres. Even if you could get every person to safety, an impact in an urban area would have severe (and potentially long-lasting) ramifications to housing, utilities, infrastructure and so on.

Instead, it would be better to avoid the impact altogether. Given a decade's notice, deflecting an asteroid is relatively straightforward in theory. If an asteroid's velocity can be slowed so that it crosses Earth's orbit a few hours later, a collision could be avoided.

Plans are already in place to test the theory by firing a projectile into an asteroid, altering its speed. This is the Asteroid Intercept and Deflection Assessment (AIDA) mission, a joint NASA/ESA venture. But the only way such a deflection plan could work on a potentially devastating asteroid is with enough advance warning. So in order to avoid disaster, it is vital we keep searching the skies. Turn the page to see which asteroids pose the most threat to Earth now and in the future. ▸

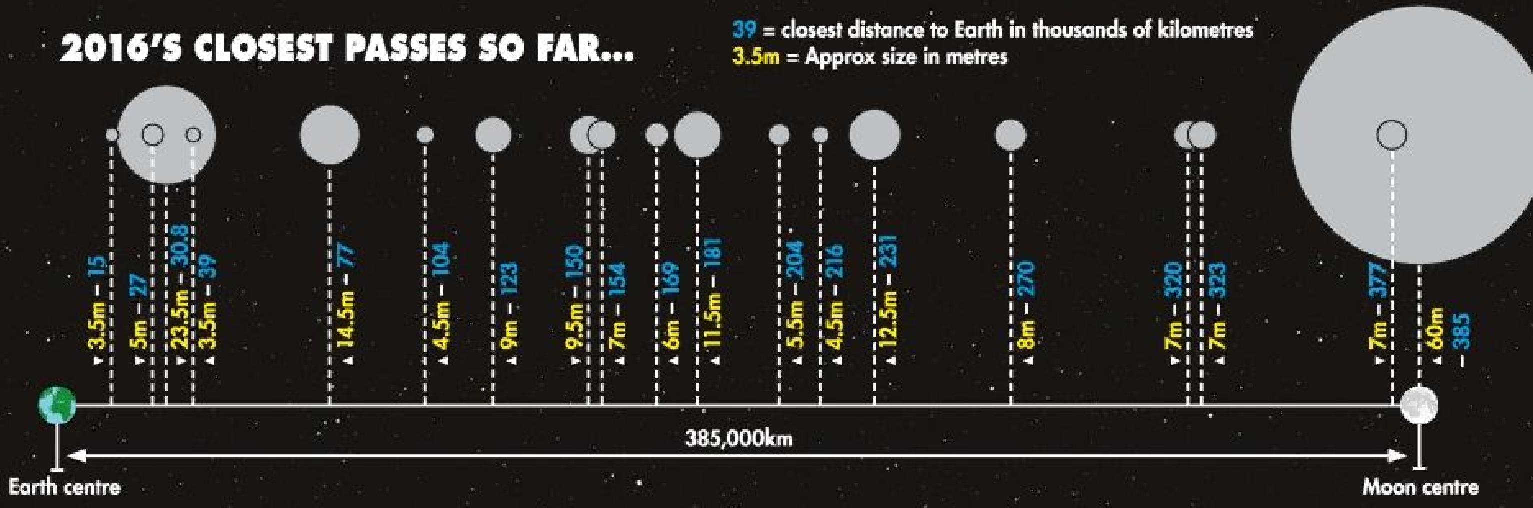
ISTOCK X 2, ESA · SCIENCEOFFICE.ORG, ESA/COMPAGNIA GENERALE DELLO SPAZIO CGS, ITAR-TASS PHOTO AGENCY/ALAMY STOCK PHOTO

TOO CLOSE FOR COMFORT

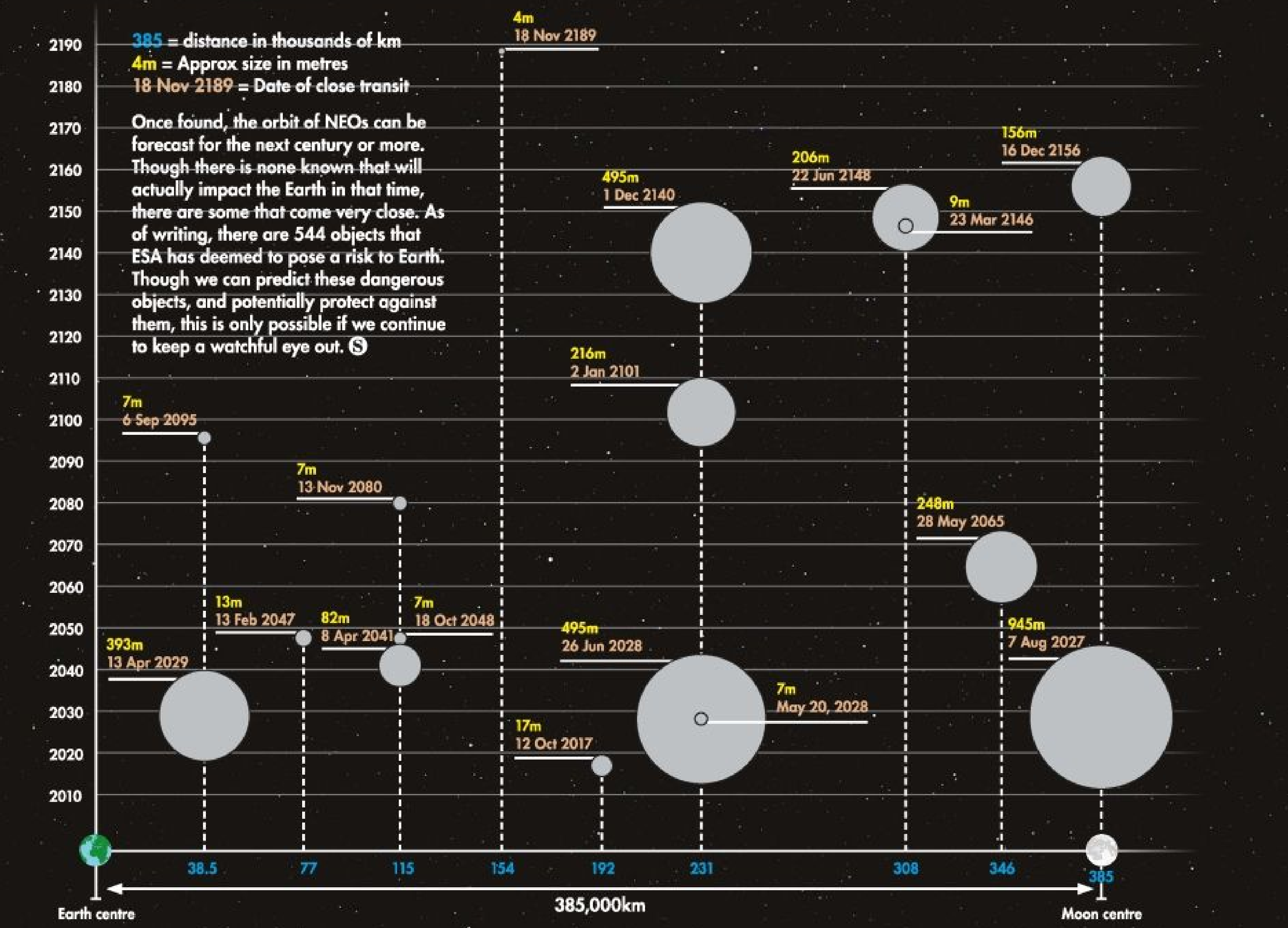
The narrow misses of the past and – thanks to early detection and forecasting – the future

▼ Years of dedicated searching have revealed more than 14,000 NEOs. Though many of these have crossed Earth's orbit, most of them did so at point far removed from our planet's actual position. But that still leaves a minority – still in the hundreds – of asteroids that come so close to Earth that they pass within the Moon's orbit every year

2016'S CLOSEST PASSES SO FAR...



CLOSEST APPROACHES IN THE NEXT 200 YEARS



Once found, the orbit of NEOs can be forecast for the next century or more. Though there is none known that will actually impact the Earth in that time, there are some that come very close. As of writing, there are 544 objects that ESA has deemed to pose a risk to Earth. Though we can predict these dangerous objects, and potentially protect against them, this is only possible if we continue to keep a watchful eye out. Ⓢ

PLUS

Stephen Tonkin's

BINOCULAR TOUR

Turn to page 58 for six of this month's best binocular sights

The Sky Guide July

Meteorology meets astronomy from late May through to early August with the possible appearance of noctilucent clouds. This beautiful phenomenon can produce some stunning displays which, once seen, will have you hooked and wanting more.

PETE LAWRENCE

Written by Pete Lawrence

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

Highlights

Your guide to the night sky this month

This icon indicates a good photo opportunity

ALL MONTH LONG

Noctilucent cloud season continues throughout July. These amazing, high-altitude clouds can sometimes be seen 90-120 minutes after sunset low in the northwest or for a similar period before sunrise low in the northeast. You never know what the season will deliver so it pays to be vigilant!

2 SATURDAY

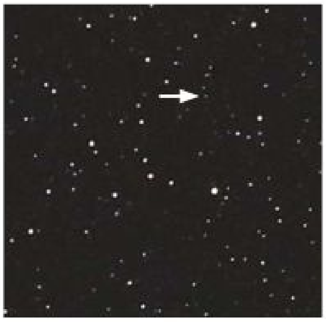
The centre of the waning crescent Moon (7% lit) is 0.5° south of mag. +0.9 Aldebaran (Alpha (α) Tauri) this morning at around 04:30 BST (03:30 UT). Aldebaran will be 0.25° north of the Moon's northern cusp. See if you can follow the star with a telescope after sunrise.

5 TUESDAY

With the Moon largely out of the way, now is a great time to try to find your way around our deep-sky tour on page 56. This month we're looking at objects in the Teapot's steam!

7 THURSDAY ▶

Dwarf planet Pluto comes to opposition today. Its dim, mag. +14.1 dot can be seen 15 arcminutes to the west-southwest of mag. +2.9 Pi (π) Sagittarii. This star is part of the asterism known as the Teaspoon. Turn to page 60 for advice on how to photograph Pluto with basic equipment.

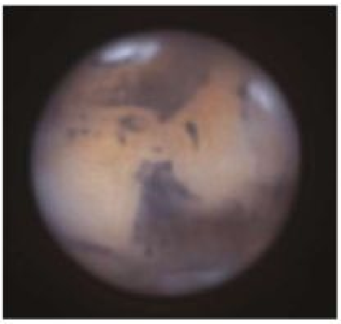


8 FRIDAY

A waxing crescent Moon (21% lit) lies 6.5° west of Jupiter at 23:00 BST (22:00 UT) this evening. There's something rather lovely about seeing the Moon near this bright, currently mag. −1.7, planet. Being summer, it'll still be twilight at this time.

11 MONDAY

The first quarter Moon sits 7° northwest of the beautiful pure white star Spica (Alpha (α) Virginis) this evening.



14 ◀ THURSDAY

Tonight, the waxing gibbous Moon (76% lit) is 6.75° north of mag. −1.1 Mars. Despite the brilliance of the Moon's glare, orange-hued Mars should stand out well.

15 FRIDAY

It's the turn of mag. +0.6 Saturn to get a visit from the Moon, now 83% lit. At 23:00 BST (22:00 UT) the Moon is 4.5° northwest of Saturn. The gap closes to around 3.75° by the time both objects are close to setting, at around 02:00 BST (01:00 UT) on 16 July.

17 SUNDAY

Despite many of them being low, there are five major planets on view after sunset. Mercury and Venus are low in the northwest with Jupiter low in the west. Saturn and Mars are both visible low in the south.

19 ◀ TUESDAY

The full Moon is low in the sky, presenting a great opportunity to try and see the Moon Illusion. This strong visual illusion makes it look as if the Moon is much larger than normal when in reality, its size is more or less the same. See page 51.

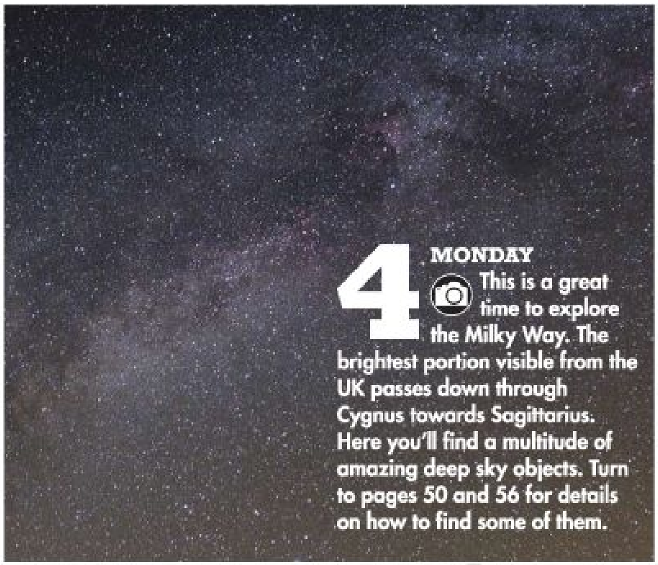
26 TUESDAY

Mag. +5.8 Uranus is just 5° north of the waning gibbous Moon (61% lit) in the early hours. At 00:30 BST (23:30 UT on the 25th) both are low in the east. At 02:30 BST (01:30 UT) the apparent gap between them will have closed to 4.3°.

28 THURSDAY

Today is the peak of the Southern Delta Aquariid meteor shower. This shower has a maximum ZHR of 15-20 meteors per hour and is normally active from 14 July to 18 August. This morning's waning crescent Moon (26% lit) should not interfere too much.

PETE LAWRENCE X 7



4 **MONDAY**

This is a great time to explore the Milky Way. The brightest portion visible from the UK passes down through Cygnus towards Sagittarius. Here you'll find a multitude of amazing deep sky objects. Turn to pages 50 and 56 for details on how to find some of them.

9 **SATURDAY ▶**

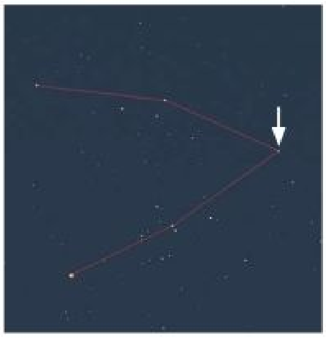
The waxing crescent Moon (30% lit) is 6° east of Jupiter at 23:00 BST (22:00 UT). This is close enough to try for a photo showing our Moon and Jupiter's Galilean moons in the same shot.

16 **SATURDAY**

Mag. –1.0 Mercury will appear just 0.5° north of mag. –3.8 Venus this evening. The pair may be glimpsed when they are very low in the northwest part of the sky just after sunset.

23 **SATURDAY ▶**

Today marks the start of the annual Perseid meteor shower; it normally shows activity from today through to 23 August. This year the peak occurs on 12 August when the ZHR may reach 150 meteors per hour. Rates will remain low throughout the rest of July.



29 **◀ FRIDAY**

The waning crescent Moon (25% lit) occults mag. +3.7 Gamma (γ) Tauri this morning. The occultation takes place at 04:24 BST (03:24 UT) from the centre of the UK, as the morning sky is brightening. Times will vary slightly with location, so it pays to view from around 03:45 BST (02:45 UT). See page 51.

What the team will be observing in July

Pete Lawrence "I'll be trying to take some photos of the low southern part of the sky passing through Sagittarius this month. There are so many beautiful deep-sky objects here that it's sometimes difficult to know where to start!"

Steve Marsh "I'm continuing to image Mars this month. I've always thought planets look beautiful before and after opposition with the shadow of phase on one limb and that's how Mars should appear at the moment."

Chris Bramley "I'm looking forward to some nice conjunctions this month, as the Moon, Mars and Saturn lie close to each other in the late evening southern skies."

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

BINOCULARS
10x50 recommended

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

SMALL/MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

Getting started in astronomy

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing a scope.

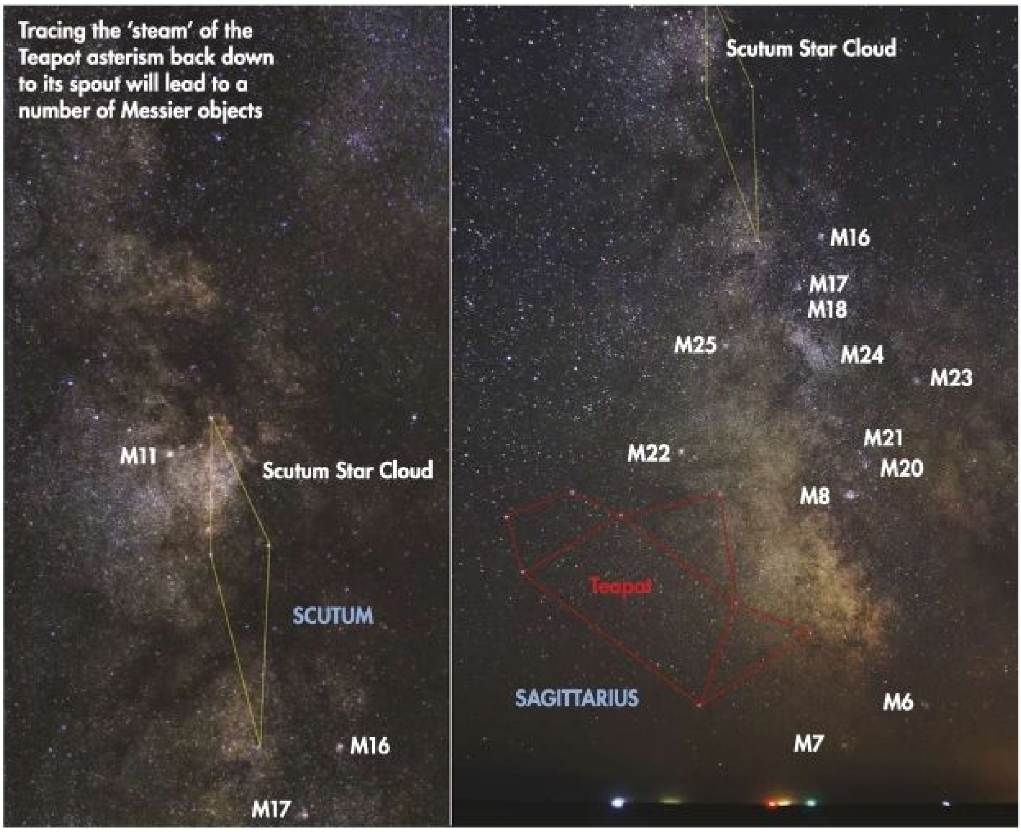
DON'T MISS... 3 top sights

Marvels of the southern Milky Way

WHEN: 1-12 and 27-31 July

NEED TO KNOW

The size of objects in the sky and the distances between them are measured in degrees. The width of your little finger at arm's length spans about 1°.


Tracing the 'steam' of the Teapot asterism back down to its spout will lead to a number of Messier objects

YOU MIGHT NOT consider viewing the Milky Way as a special timed event. After all, it's a fixed part of the night sky, and so is visible for a good part of the year. However, the core region is a little different in that it requires accurate timing, luck with the weather and persistence to see.

From the UK, the most prominent portion of the Milky Way passes down through Cygnus, appearing to follow the vertical of the Northern Cross. From a dark site the Milky Way appears to split in two here. Known as the Cygnus Rift, the split is caused by dark dust blocking the light of the more distant background stars. The two misty sections head southward, one ending off the shoulder of Ophiuchus. The other passes closer to the centre of Aquila and keeps heading southward.

It flows into Scutum and past the wonderful Wild Duck Cluster, M11. This is glorious in any size of telescope. A patch of the Milky Way known as the Scutum Star Cloud brightens in this region. From a dark sky site, the star cloud is bright enough to trick the unwary into thinking weather clouds are heading in to spoil the show.

Things get interesting southeast of Scutum. The first main object is M16, the Eagle Nebula. With binoculars and a small or medium telescope, it looks as if the nebula has flown the nest, as all that tends to be seen is the cluster that formed out of the nebula gas. To the south is M17, the Swan or Omega Nebula. This is a rather lovely object and easy to see as a nebula, even with small instruments. Continue south and you'll reach M24, or Delle Caustiche. This is another Milky Way star cloud full of embedded clusters. To the east lies the wonderful open cluster M25, rich and easy to see with small instruments.

Farther south still we approach the top of the famous Teapot asterism in Sagittarius. Close to the top of the lid is the greatly underappreciated globular cluster M22. Despite its low altitude, a dark sky view of it from the UK can still reveal its spectacular beauty.

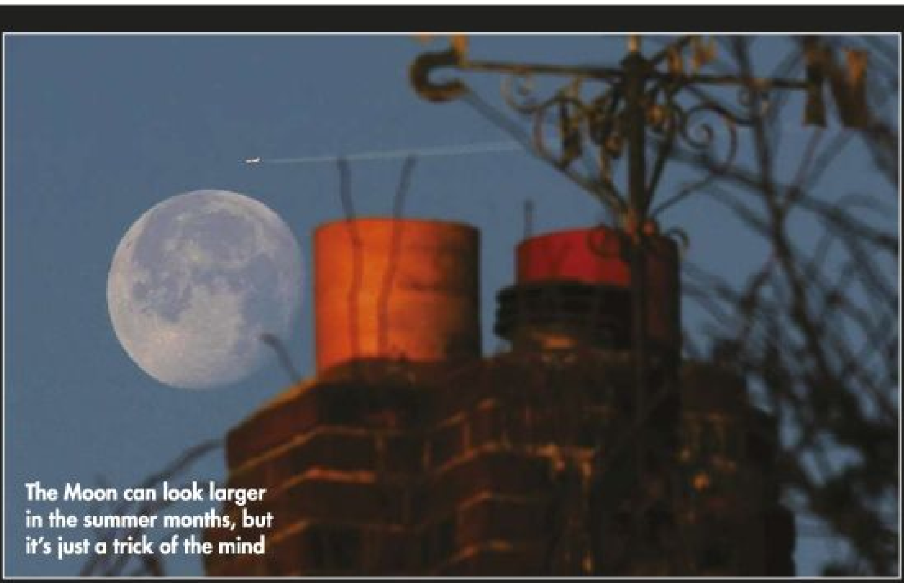
Farther west we enter the amazingly rich region where the steam would be rising out of the Teapot's spout. Here you'll find objects such as M8, the Lagoon Nebula, and M20, the Trifid Nebula. Despite being very low from the UK, they do reward persistence. For more details of the delights on offer in the 'steam', turn to page 56 and follow our low, southern deep-sky tour.

▲ M24, or Delle Caustiche, is a star cloud rich with open clusters

PETE LAWRENCE X4

Moon illusion

WHEN: 17-21 July



The Moon can look larger in the summer months, but it's just a trick of the mind

WHEN A FULLER phase of the Moon appears low down and close to the horizon, it can look huge. This effect is known as the Moon illusion, and it is common in the summer months.

Around this time the full Moon and the wide gibbous phases that precede and follow it occur when the Moon is travelling along a southern region of the ecliptic. Consequently, these phases appear low in the sky and close to the southern horizon. Moonrise and moonset tend to occur with the Moon moving at a shallow angle to the horizon and this creates a perfect situation for experiencing the Moon illusion.

The illusion can be very pronounced and even when you know that the Moon is in reality no larger than normal, it's hard to overrule what your brain is telling you must be the case. Bizarrely, a low lunar disc will, if anything, be smaller than when it's high up. The optical properties of the atmosphere will squash it vertically and the Moon's distance will be an Earth radii further away than if it were directly overhead.

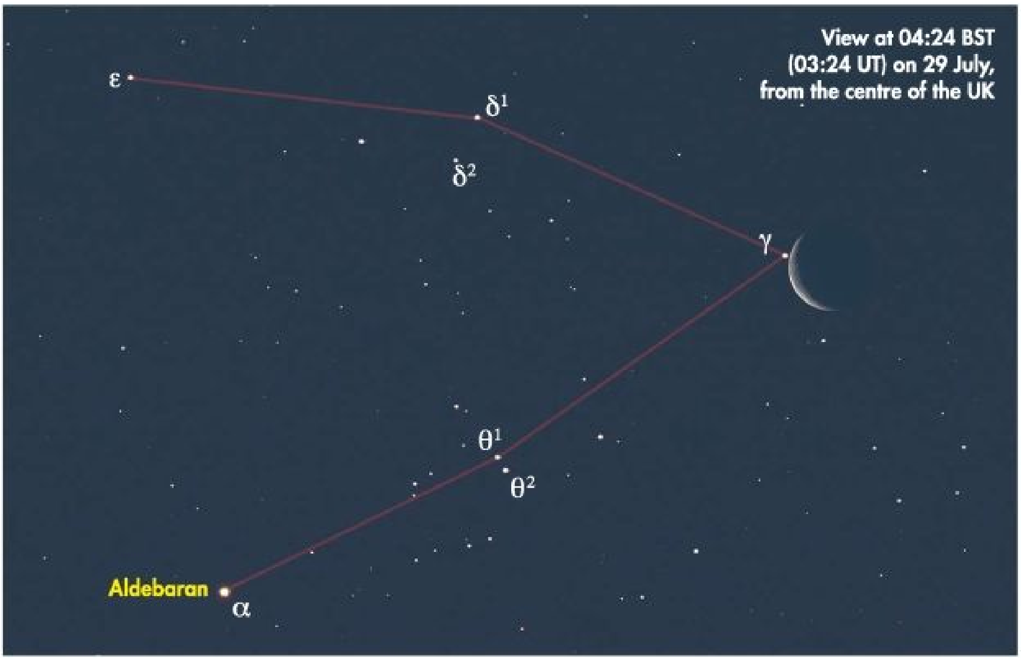
There are many theories as to why the effect occurs. One of the more convincing ideas is that we perceive the sky above our heads as a flattened dome. When we see something close to the horizon, our brains believe it to be farther away and apply a mental correction to its size. You can verify how small the apparent size of the Moon is by holding up your little finger at arm's length. It'll easily cover the Moon's disc, despite what the illusion wants you to believe! If the illusion really bothers you, one solution that apparently works is to view the Moon while standing on your head.

Lunar occultation of Gamma Tauri

WHEN: 29 July, view from 03:45 BST (02:45 UT)

A 25%-LIT waning crescent Moon rewards early risers or all-nighters on 29 July. In the early hours it occults mag. +3.7 Gamma (γ) Tauri, the star marking the pointed tip of the V-shaped open cluster known as the Hyades.

From the centre of the UK the occultation takes place at 04:24 BST (03:24 UT) as the sky is starting to get bright with the approach of sunrise. The brightening sky could prove a bit of a challenge when trying to keep the star in view, but it should be achievable with a telescope. The best strategy is to catch the star earlier in the morning, say at around 03:45 BST (02:45 UT), when the sky brightness will still be dark enough to allow it to be easily seen. The sky will then brighten as the apparent distance between the Moon and Gamma Tauri decreases.



View at 04:24 BST (03:24 UT) on 29 July, from the centre of the UK

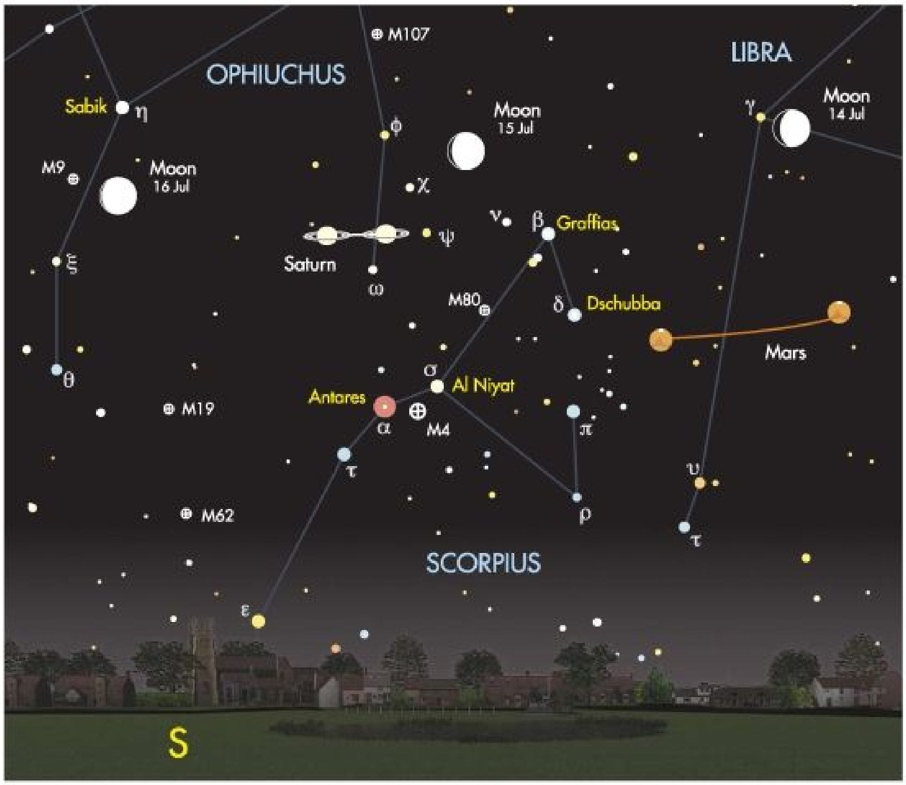
It's the Moon's bright limb that the star will vanish behind. The trick to occultations is to simply keep watching. No matter how well you think you can anticipate when the edge of the Moon will hide the star, the reality is often different. A lack of lunar atmosphere combined with the star effectively being a point source means that the disappearance is instantaneous. Blink at the wrong moment and you'll miss it.

The planets

PICK OF THE MONTH

MARS

BEST TIME TO SEE: 1 July, 23:00 BST (22:00 UT)
ALTITUDE: 15°
LOCATION: Libra
DIRECTION: Just west of south
FEATURES: Polar caps, albedo markings, atmospheric clouds
EQUIPMENT: 3-inch refractor



▲ The Red Planet is low and getting dimmer – to see it at its best, seek it out at the start of July

MARS WAS AT opposition at the end of May, when it appeared brightest and telescopically largest for this current apparition. Now the distance between Earth and Mars is increasing once more and this is having a dramatic effect on the planet's appearance. At the start of July, Mars is a dominant sky object, its salmon-pink dot shining away at mag. –1.4. Through a telescope its disc appears 16.3 arcseconds across and isn't quite round, exhibiting a 93%-lit waning gibbous phase. As the month progresses, Mars will get dimmer and smaller. By 31 July, it'll have dimmed to mag. –0.8 and, telescopically, detail will be harder to see on its now 13.1-arcsecond disc. Its phase will be more noticeable too, dropping to 87% lit.

▲ Mars is closing in on Saturn and Antares now it has resumed its eastward march

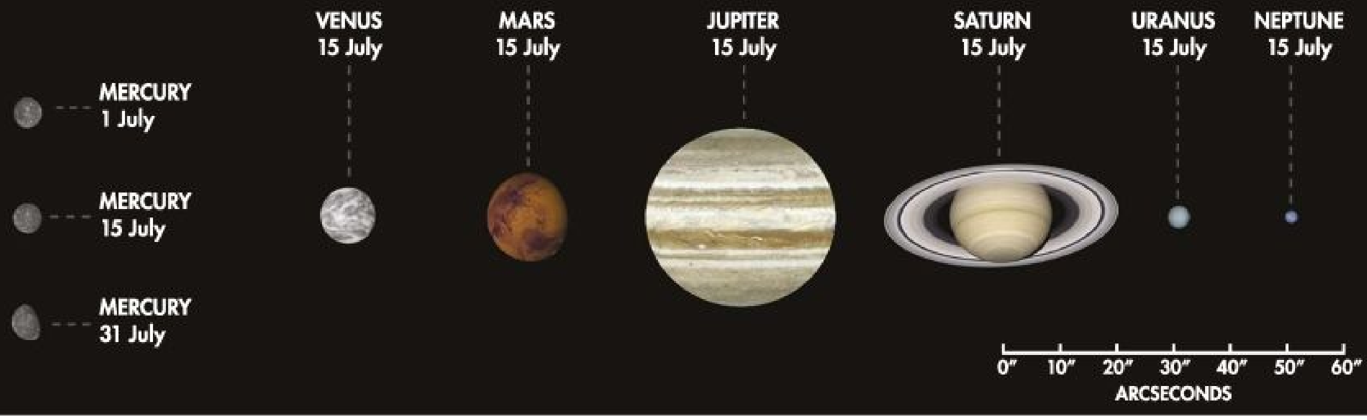
PETE LAWRENCE X 3

Mars changed direction at the end of June. Throughout that month it could be seen gradually moving westward against the stars. It reached the middle of Libra on 30 June as its westward motion came to a halt. After reaching what is known as a stationary point, Mars is now resuming its normal eastward motion, heading back towards its rival, the red star Antares (Alpha (α) Scorpii), and yellow-hued Saturn.

Both Mars and Saturn are low in the sky as seen from the UK. This situation isn't helped by the fact that Mars is past the meridian as darkness falls during July. The consequence of this is that it'll be even lower in the sky when sufficiently dark to get a decent view of it. The best time to catch Mars is right at the start of July when it'll be at its brightest and largest for the month. Pick it up with a telescope from just after 22:00 BST (21:00 UT) and it'll be around 15° up from the centre of the UK, just west of the meridian.

THE PLANETS IN JULY

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



SATURN

BEST TIME TO SEE: 1 July, 23:00 BST (22:00 UT)
ALTITUDE: 16.5°
LOCATION: Ophiuchus
DIRECTION: South

Saturn can be seen low in the southern part of the sky as darkness falls. The planet is in Ophiuchus, not too far from Mars and 6° north of supergiant star Antares (Alpha (α) Scorpii). Now past opposition, Saturn shines at mag. +0.2 at the start of July, dimming a fraction to +0.3 by month end. Its rings are tilted toward Earth by 26° with Saturn's north pole on display. While we have to mention the fact that Saturn has a low altitude from the UK, if you can get a look at it through a telescope those wide open rings are sure to delight.

NEPTUNE

BEST TIME TO SEE: 31 July, 02:30 BST (01:30 UT)
ALTITUDE: 28°
LOCATION: Aquarius
DIRECTION: Just east of south

Neptune is in Aquarius, 0.5° south of mag. +3.7 Lambda (λ) Aquarii. It almost manages to culminate in darkness this month. At mag. +7.8, Neptune requires binoculars to see.

URANUS

BEST TIME TO SEE: 31 July, 02:30 BST (01:30 UT)
ALTITUDE: 30°
LOCATION: Pisces
DIRECTION: East-southeast

The lengthening nights are working in the favour of the ice giants Uranus and Neptune. Uranus reaches an altitude of 30° at the end of July in reasonably dark skies. It's located in Pisces, 2° and 40 arcminutes north of mag. +4.8 Mu (μ) Piscium. It remains at mag. +5.8 all month, right on the edge of naked-eye visibility from a moderately dark site.

JUPITER

BEST TIME TO SEE: 1 July, 23:00 BST (22:00 UT)
ALTITUDE: 10°
LOCATION: Leo
DIRECTION: West

Jupiter is now past its best for the current observing period. It can be found low down in the west as darkness falls, chasing Venus and Mercury towards the location of sunset. It shines at mag. –1.8 for most of July.

MERCURY

BEST TIME TO SEE: 16 July, 20 minutes after sunset
ALTITUDE: 2.5° (low)
LOCATION: Cancer
DIRECTION: Northwest

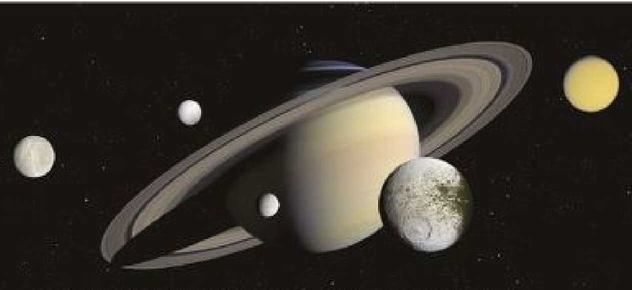
Mercury starts the month in the morning sky but is rapidly lost from view, as it enters superior conjunction on the 7th. It then emerges in the evening sky and has a close encounter with Venus on the 16th. Mercury will be mag. –1.1 and will pass 0.5° from mag. –3.9 Venus. The pair are low down from the UK, but the brightness of both objects should improve their visibility given clear skies. Look for them about 20 minutes after sunset, close to the northwest horizon. By 31 July, Mercury's brightness will have dropped to –0.2, but it should still be visible just after sunset, to the left of Venus. Its phase changes from almost full on 16 July, to 67%-lit on the 31st.

VENUS

BEST TIME TO SEE: 31 July, 30 minutes after sunset
ALTITUDE: 2° (low)
LOCATION: Leo
DIRECTION: West-northwest

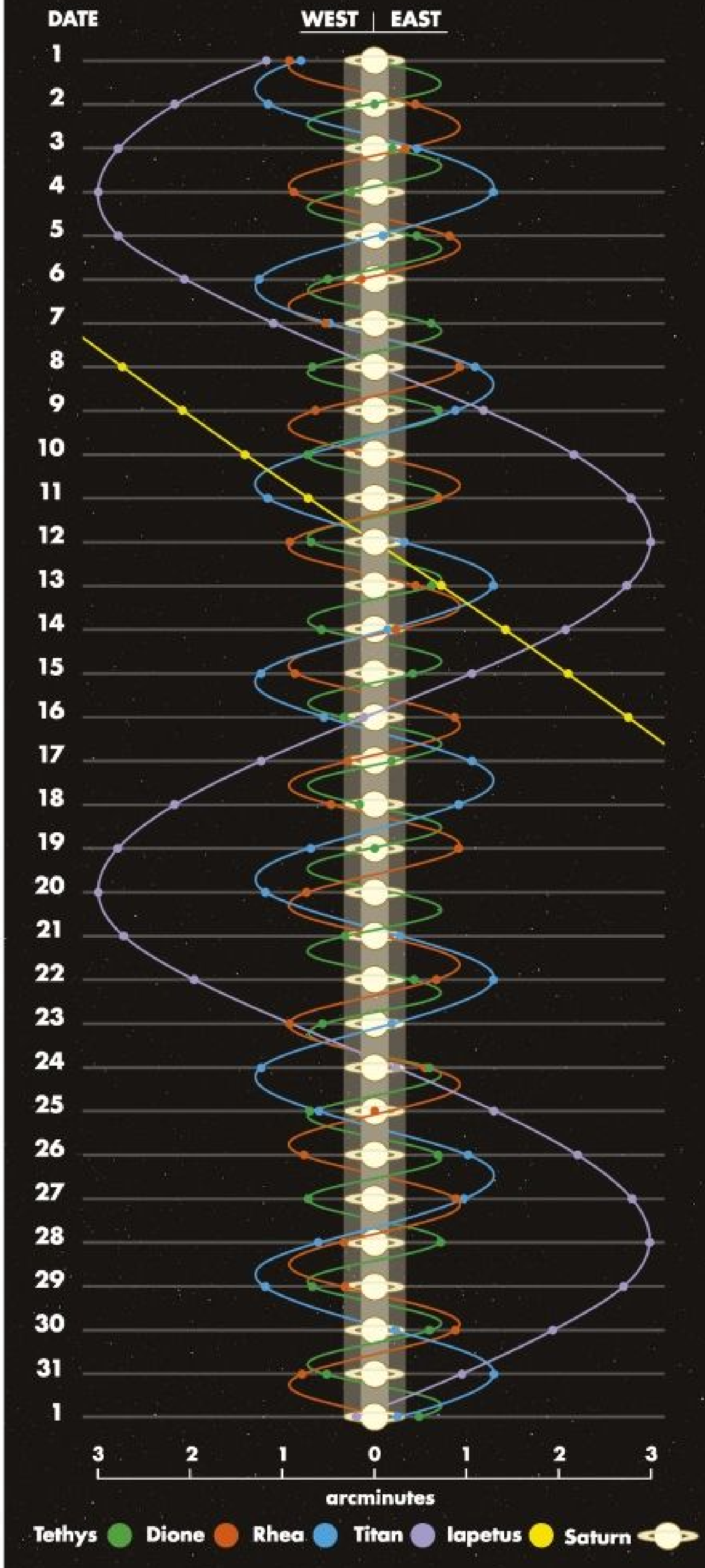
Venus is slowly increasing its separation from the Sun. Unfortunately it's not very high in the sky after sunset, so is easily lost behind foreground objects. A good flat horizon is essential to see it. There's a close, 0.5° conjunction with Mercury on 16 July. Venus's brightness remains at a steady mag. –3.9, and through a scope appears as a 10-arcsecond, almost full, disc.

YOUR BONUS CONTENT Planetary observing forms



SATURN'S MOONS
July

Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



The Northern Hemisphere

KEY TO STAR CHARTS

Arcturus	STAR NAME
PERSEUS	CONSTELLATION NAME
⬭	GALAXY
◌ ⁘	OPEN CLUSTER
⊕	GLOBULAR CLUSTER
☼	PLANETARY NEBULA
□	DIFFUSE NEBULOSITY
●	DOUBLE STAR
○	VARIABLE STAR
◐	THE MOON, SHOWING PHASE
☄	COMET TRACK
●–●	ASTEROID TRACK
┈	STAR-HOPPING PATH
△	METEOR RADIANT
Circlet	ASTERISM
🪐	PLANET
☼	QUASAR

STAR BRIGHTNESS:

⬤	MAG. 0 & BRIGHTER
●	MAG. +1
•	MAG. +2
·	MAG. +3
.	MAG. +4 & FAINTER
N W S E	COMPASS AND FIELD OF VIEW
	MILKY WAY

WHEN TO USE THIS CHART

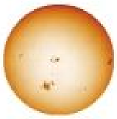
1 JULY AT 01:00 BST
15 JULY AT 00:00 BST
31 JULY AT 23:00 BST

On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

THE SUN IN JULY*



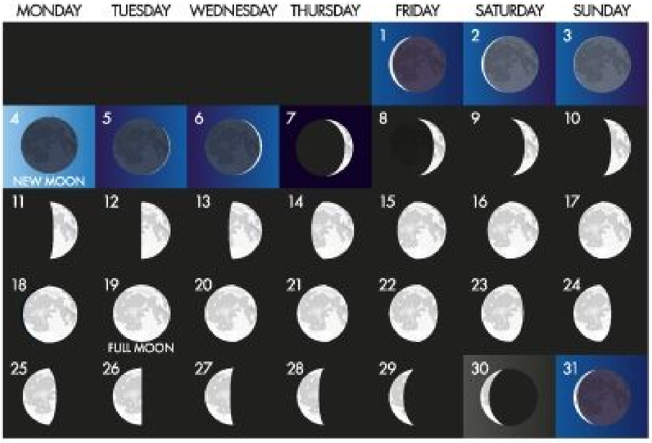
DATE	SUNRISE	SUNSET
1 Jul 2016	04:46 BST	21:41 BST
11 Jul 2016	04:55 BST	21:34 BST
21 Jul 2016	05:09 BST	21:22 BST
31 Jul 2016	05:24 BST	21:06 BST

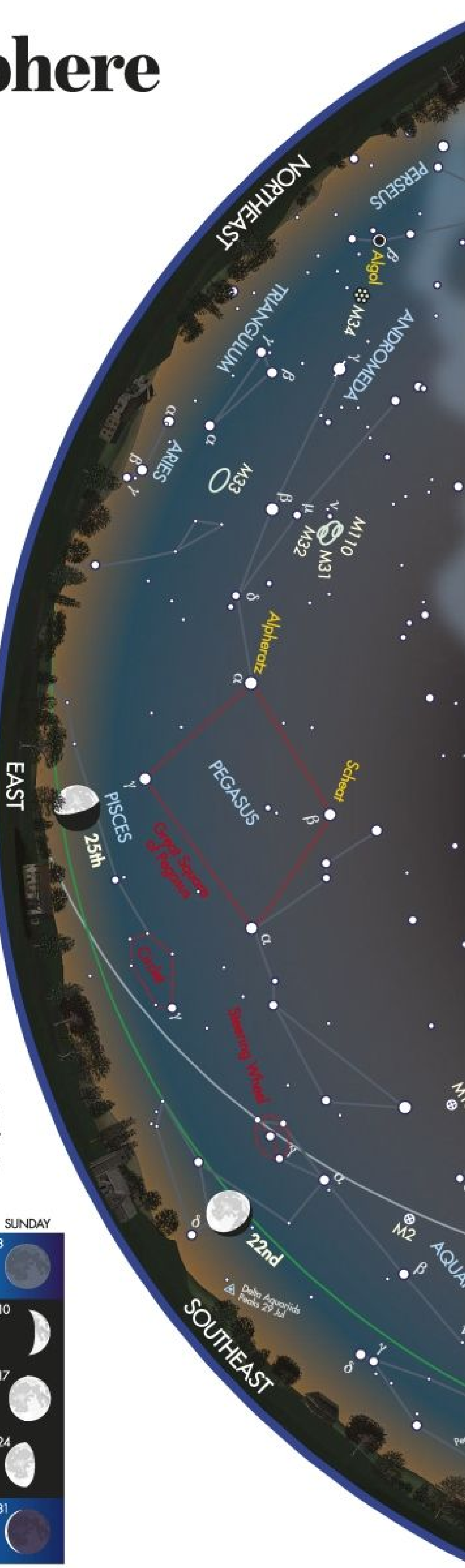
THE MOON IN JULY*

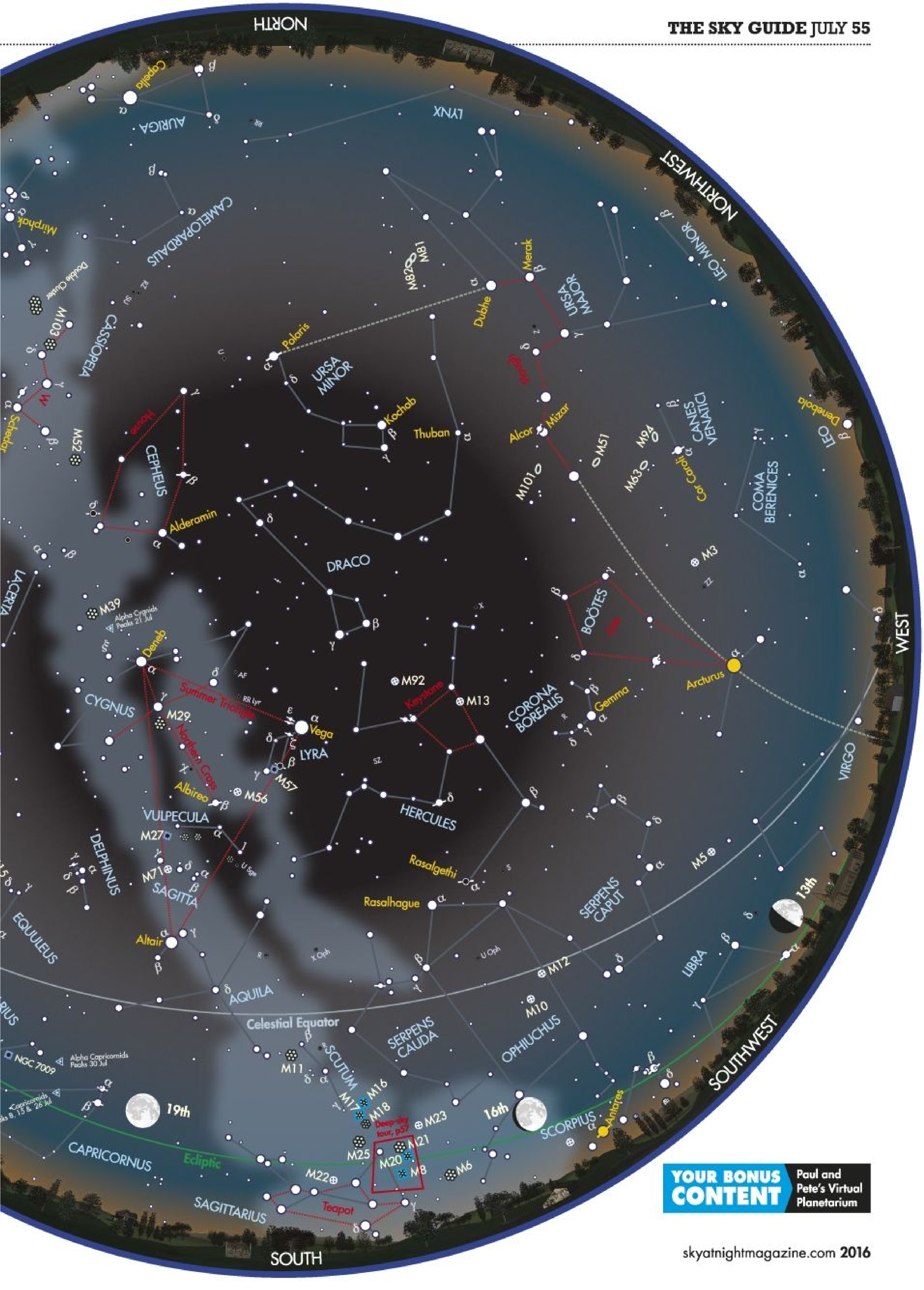
MOONRISE TIMES

1 Jul 2016, 02:44 BST
5 Jul 2016, 06:14 BST
9 Jul 2016, 10:51 BST
13 Jul 2016, 15:10 BST
17 Jul 2016, 19:11 BST
21 Jul 2016, 21:58 BST
25 Jul 2016, 23:46 BST
29 Jul 2016, 01:23 BST

***Times correct for the centre of the UK**





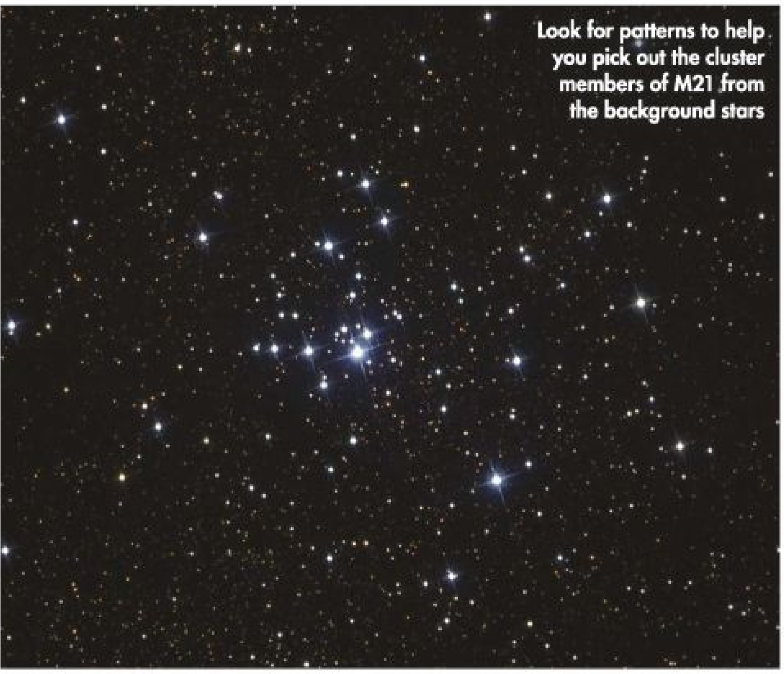


YOUR BONUS CONTENT Paul and Pete's Virtual Planetarium

Deep-sky tour

Explore two classic targets in the Teapot's steam, plus four more you might have overlooked

☑ Tick the box when you've seen each one



Look for patterns to help you pick out the cluster members of M21 from the background stars

1

M21

This month's deep-sky tour takes in some of the fascinating objects located just off the spout of the Teapot asterism in Sagittarius – where the steam would rise. We'll start with the mag. +6.5 open cluster M21, 2.5° southwest of mag. +3.8 Mu (μ) Sagittarii. A 6-inch scope shows this cluster as 25 or so stars concentrated into an area 0.25° across. Lying within the Milky Way's boundary, it can be a little tricky to see where the cluster ends and the background stars begin but there are a number of patterns to assist you. There's a noticeable line of stars starting in the southeast corner. In the southwest corner the line terminates with a dominating pair of slightly brighter stars. What's best described as a star loop spreads north from this arrangement. The cluster contains just shy of 60 members. ☐ **SEEN IT**

2

THE TRIFID NEBULA

When looking at M21 with a low-power eyepiece it is hard to ignore its rather superb neighbour M20, the Trifid Nebula. If you look closely, a string of stars appears to guide the way towards the nebula and its associated cluster. A small scope first reveals two mag. +7.5 stars separated by 8 arcminutes. A hazy region surrounds both stars, most evident around the southern one which, at 100x magnification, can be seen to be a close pair 11 arcseconds apart. Three non-linear dark lanes can be seen converging on this pair. These are separated by approximately 120°, the northeast lane being the largest and easiest to spot. It's the way these lanes divide the nebula that gives M20 its familiar name. ☐ **SEEN IT**

THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

3

NGC 6546

After the excitement of M20, it's hard to move on to something less dramatic, but we must before visiting the main attraction. NGC 6546 is an 8th-magnitude open cluster located just over 1° to the east-southeast of M20, and another that struggles to make itself known against the background glow of the Milky Way. A 10-inch scope reveals about 30 stars in a region roughly 10 arcminutes across, the brightest members of which are around mag. +11.0. Three 9th-magnitude stars are located on the eastern side of the cluster, and these help in NGC 6546's identification as they are arranged in a distinctive right-angled triangle pattern. ☐ **SEEN IT**

4

THE LAGOON NEBULA

The main attraction in the Teapot's 'steam' has to be M8, the Lagoon Nebula. This is a big, bright and bold nebula, a worthy rival to M42 in Orion's Sword if it wasn't for the fact that from the UK it's much lower in the sky. To find it, look south and slightly west from NGC 6546 for about 1.3°, but to be frank it's hard to miss! The object incudes a mag. +4.6 open cluster (NGC 6530) to the east; a dark lane separates this from the brightest portion of M8 to the west. The nebula is 90x40 arcminutes and easily visible in even a small telescope. Two brighter stars lie close to the west edge of the dark lane, mag. +5.9 9 Sagittarii and mag. +7.1 TYC-6842-1472-1. The brightest and most obvious part of the emission nebula sits just over 2 arcminutes to the southwest of 9 Sagittarii. ☐ **SEEN IT**

5

NGC 6544

A change of pace from the sumptuously detailed M8 now as we head 1° to the southeast to our next target, the mag. +8.1 globular cluster NGC 6544. This is a relatively small object, appearing just 3 arcminutes in diameter. A 6-inch scope will resolve some of its boundary stars, but the rest will remain a haze. A 10-inch scope with a medium- or high-power eyepiece will start to reveal a granular appearance across the cluster's core. It's also evident that this isn't a round globular, being elongated northwest-southeast. ☐ **SEEN IT**

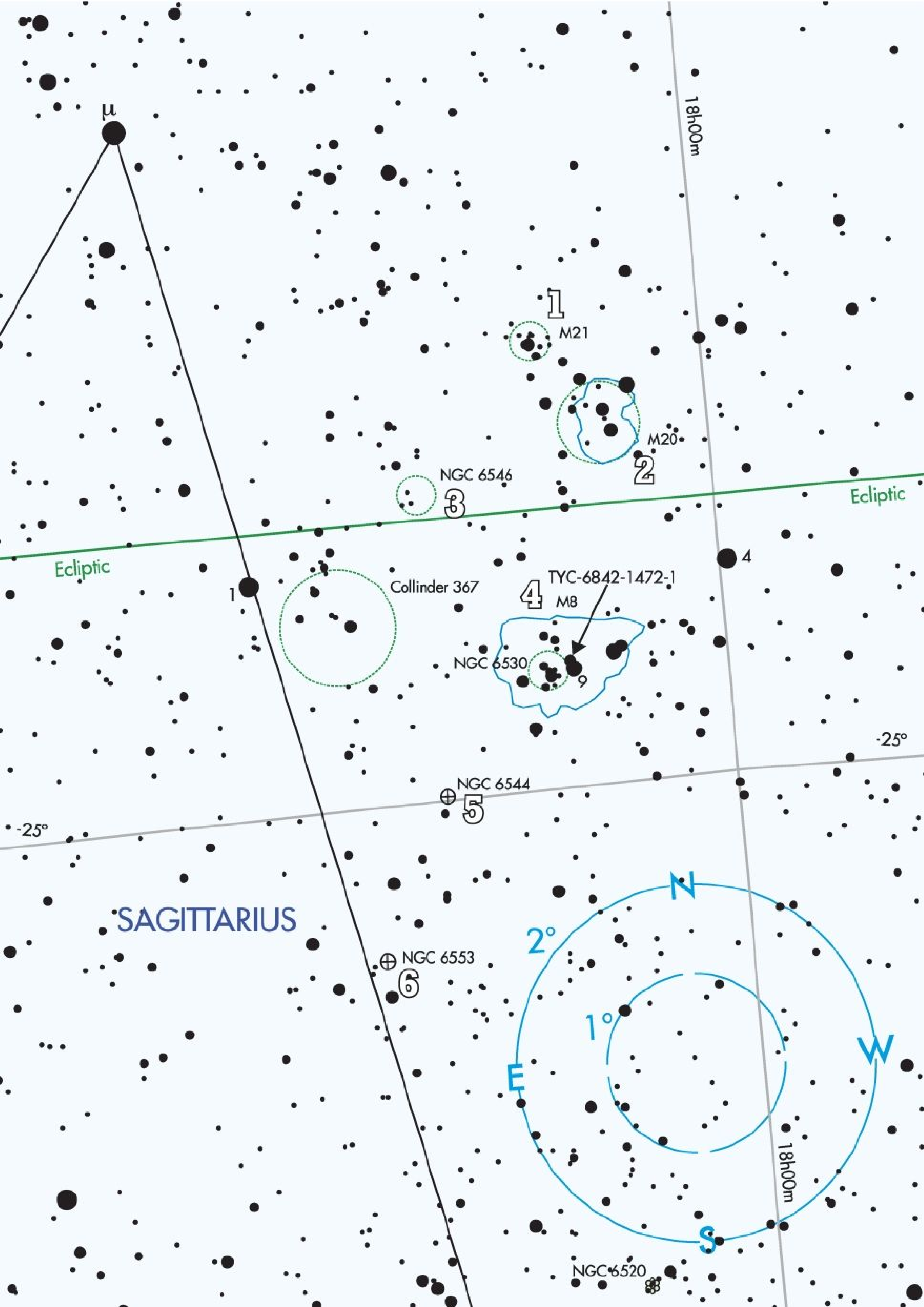
6

NGC 6553

Our final object is another globular cluster located 1° to the southeast of NGC 6554. At mag. +8.1, it's of similar magnitude to NGC 6544 and of similar apparent size, though perhaps a little smaller, and its core is also elongated. It was discovered by William Herschel in 1784, the first of 37 new globulars he would find. A large scope at high power shows the main core to be surrounded by an irregularly shaped and mottled halo. The hazy appearance of NGC 6553 through a small telescope may make it a challenging target for light polluted skies. ☐ **SEEN IT**

YOUR BONUS CONTENT Print out this chart and take an automated Go-To tour

CHART: PETE LAWRENCE, PHOTO: MICHAEL BREITE/STEFAN HEUTZ/ WOLFGANG RIES/CCDGUIDE.COM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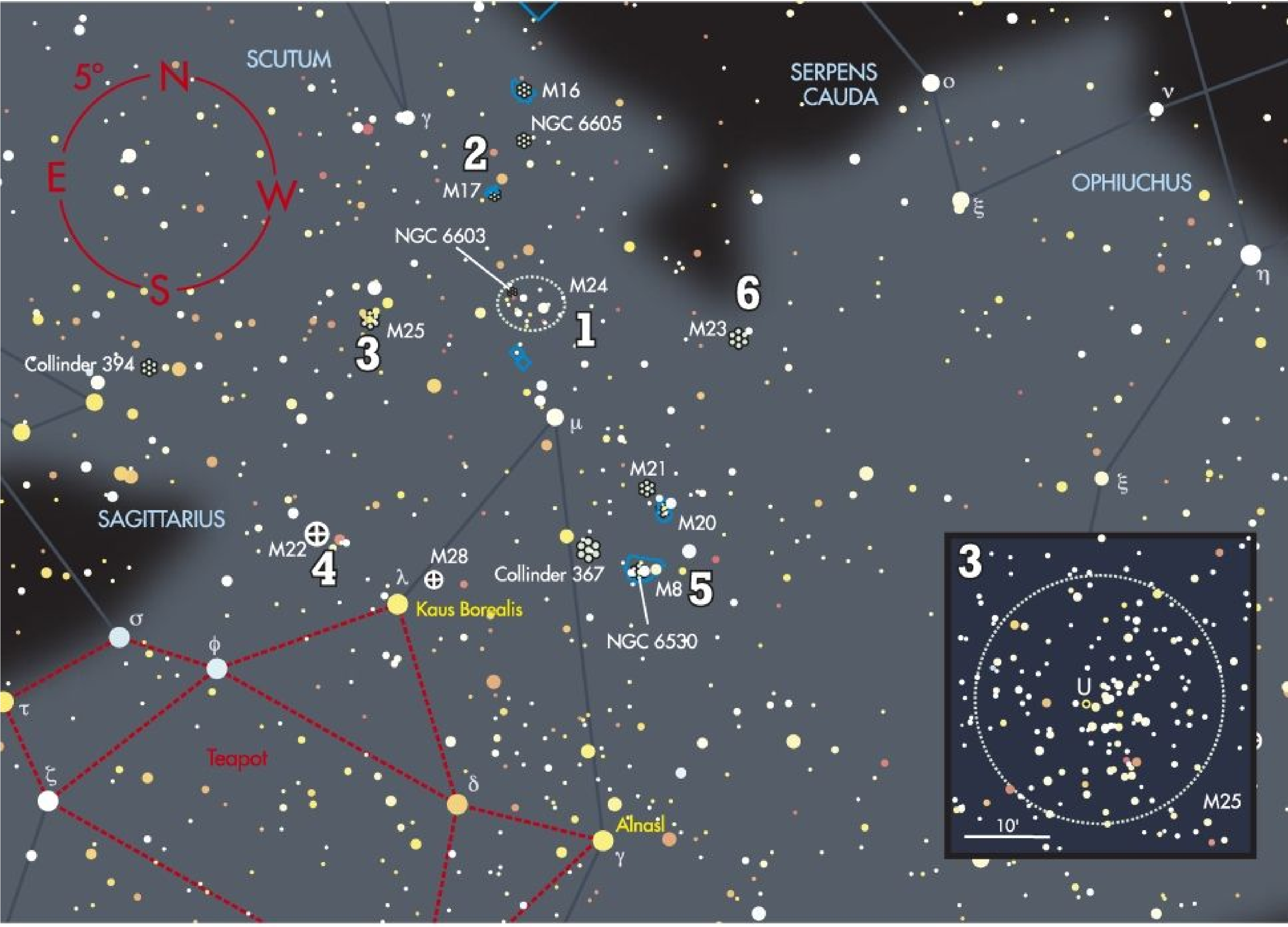
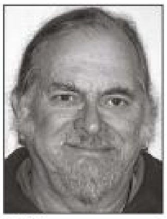




With
Stephen Tonkin

Binocular tour

A window to the Milky Way and the largest globular visible from the UK await in July

☑ Tick the box when you've seen each one

1 SAGITTARIUS STAR CLOUD

10x50 M24, the Sagittarius Star Cloud, lies slightly more than halfway from mag. +4.7 Gamma (γ) Scuti to mag. +3.8 Mu (μ) Sagittarii. It is a bright patch of light that is easily visible to the naked eye and often mistaken for a cloud just above the horizon. It is part of the Sagittarius arm of the Milky Way that we see through a gap in the intervening dust cloud. A pair of 10×50s will reveal over 1,000 stars in a single field of view! As a galactic arm, it also contains many open clusters. NGC 6603 is the most visible of these, appearing as a brighter patch in the northeast of the cloud. ☐ **SEEN IT**

2 THE SWAN NEBULA

15x70 M17, also known as the Swan or Omega Nebula, is a little over 2° north of M24. You should initially see it as an elongated oval patch of greyish light about 10 arcminutes long. Keep it centred while you concentrate your gaze on the mag. +5.3 star about 0.5° north of it, and averted vision should reveal a small hook-like extension extending south from the top of the patch. This gives the nebulosity the appearance of an inverted tick-mark rather than the letter omega or a swan. ☐ **SEEN IT**

3 M25 AND U SAGITTARII

10x50 Navigate 4° to the southeast to find the bright (mag. +4.6) open cluster M25. It appears distinctly against the background Milky Way, with 10x50s resolving eight or so stars against a grainy background in suburban skies. The cluster is unusual in that it has few blue-white stars. Embedded within is Cepheid variable U Sagittarii, which has a magnitude range of +6.3 to +7.2 and a period of 6.75 days. There is a clear relationship between a Cepheid's period and luminosity, and they are therefore useful as 'standard candles' for establishing distances. ☐ **SEEN IT**

4 M22

10x50 Place mag. +2.8 Kaus Borealis (Lambda (λ) Sagittarii), the star at top of the lid in the Teapot asterism, in the southwest of your field of view. M22 should be obvious near the centre. This is a beautiful globular cluster that shows a very much brighter core, reminiscent of the coma of a comet. It is the third largest of the southern hemisphere globular clusters and the largest globular visible from the UK – an accolade often erroneously bestowed on M13. ☐ **SEEN IT**

5 THE LAGOON NEBULA

10x50 If you imagine Kaus Borealis and mag. +3.0 Alnasl (Gamma (γ) Sagittarii) as being the base of an equilateral triangle, the Lagoon Nebula is at the third apex, due north. Designated M8, the nebula is visible to the naked eye in reasonably dark skies if it is well clear of the horizon murk. Even small binoculars will show a few stars of the associated open cluster (NGC 6530), and 10×50s will show more than half a dozen stars and some of the surrounding nebulosity (NGC 6523) that they illuminate, as well as the denser cluster of stars to the east of the main nebulosity. ☐ **SEEN IT**

6 M23

15x70 Open cluster M23 is just over halfway from mag. +3.5 Xi (ξ) Serpentis back to Mu Sagittarii. This bright, oval cluster is a beautiful sight in 15x70s, through which you should see about a dozen stars in the shape of a lower case letter alpha (α) against an ethereal background glow that merges with the background Milky Way. M23 is only 2,150 lightyears distant, which is why it appears to be a relatively large 15×27 arcminutes. ☐ **SEEN IT**

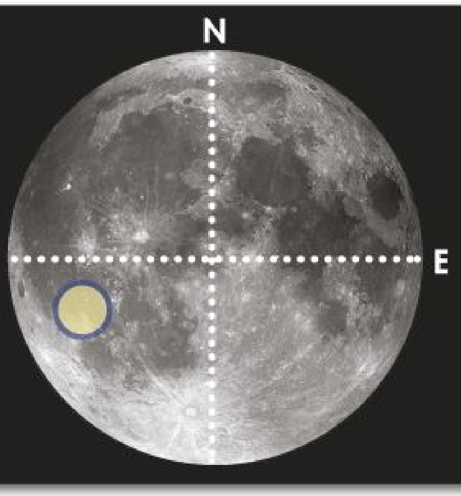
CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

Letronne

STATISTICS

TYPE: Flooded crater
SIZE: 119km diameter
AGE: 3.8-3.9 billion years
LOCATION: Latitude 10.5°S, longitude 42.5°W
BEST TIME TO OBSERVE: Four days after first quarter or three days after last quarter (15-16 July and 29-30 July)
MINIMUM EQUIPMENT: 10x binoculars



CRATER LETRONNE SITS in the southwest region of Oceanus Procellarum, on the northern edge of a bright region sometimes referred to as the Gassendi Highlands, which divide Procellarum from the Mare Humorum to the south. The best way to identify Letronne is to first locate the far more dramatic crater Gassendi (110km wide) on the northern edge of Mare Humorum. Keep heading north of Gassendi, veering slightly to the west, and the first similarly sized feature you come to is Letronne.

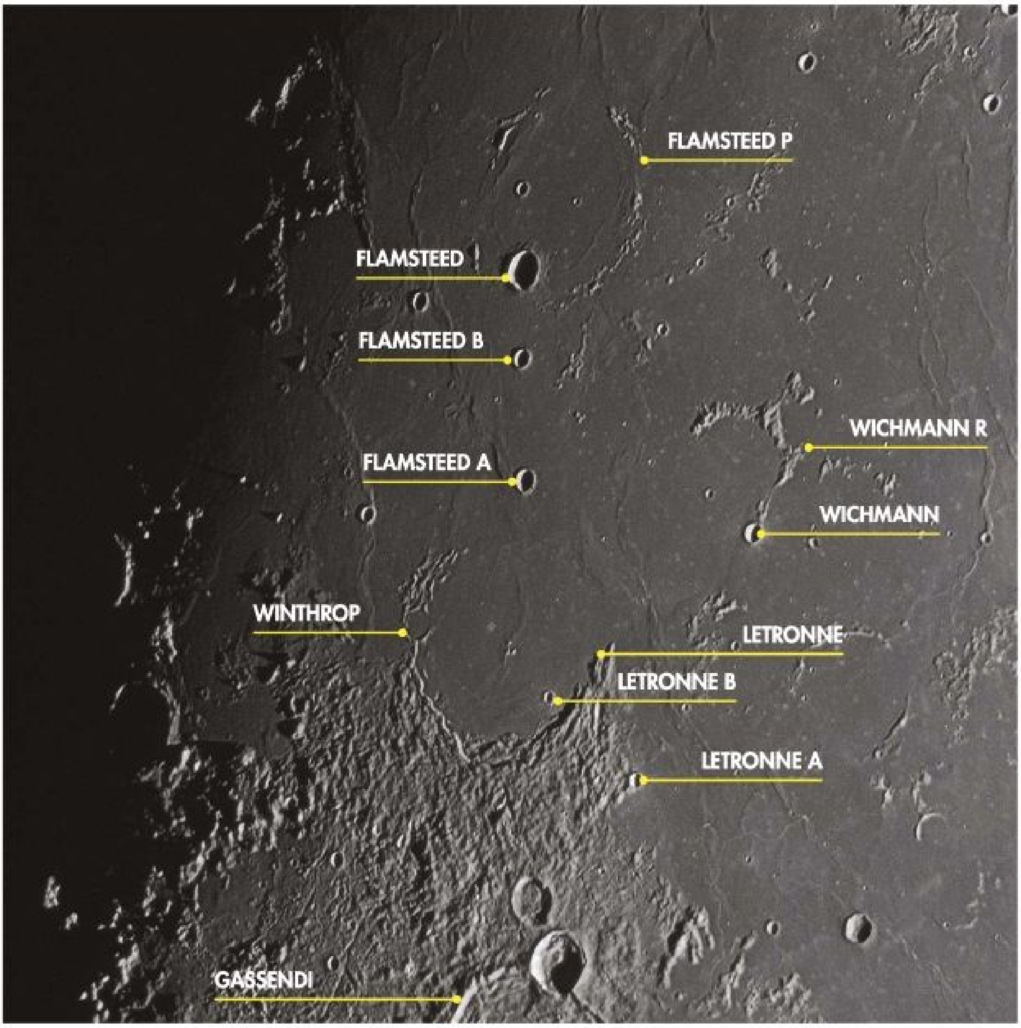
The similarity between both craters ends with their size. Letronne is an old, flooded crater that has completely lost part of its northern rim under the surface of the Oceanus Procellarum. The remaining outline is more reminiscent of a lunar bay than a crater.

The western rim appears bright under high illumination, contrasting well against the dark lava of Procellarum's surface. Under low, oblique illumination, the limited height of this portion of Letronne's rim casts shadows that reveal it to be comprised of small arcs, concentric with Letronne's centre. Even here, ancient Letronne is not left undisturbed, as the ridges are interrupted at their southern end by Winthrop (18km), another flooded crater with a section of its own rim hidden under Procellarum's lava.

Letronne's southern rim is old and eroded but easy to follow. It curves up in the east to form the most defined part of the rim, with terraced remains towering above the floor below. Again, low, oblique light is best to see this region, preferably during a waxing gibbous phase, as then the dark shadows cast impressively across Letronne's flat floor. When the Sun is low in the lunar sky from Letronne, a north-south wrinkle ridge can be seen curving slightly down the northern radius of the crater. It passes through a small group of mountains, the bulk of which have been swallowed by lava. Only three tiny but bright peaks remain, creating a distinctive triangular pattern right in crater's centre.

The largest crater inside Letronne is 5km Letronne B, in its southeast quadrant. Letronne A can be found by extending a line from the centre of Letronne, through Letronne B and on for about the same distance again. Despite its diminutive 7km diameter, Letronne A stands out rather well because it is young and bright. A small region of light ejecta can also be seen surrounding it.

To the northeast is 10km Wichmann with half a crater to the north of it. This is what's left of 62km Wichmann R. Immediately north of Letronne lies 11km Flamsteed A, then 10km Flamsteed B. Keep going to arrive at the distinctive 22km crater Flamsteed. This lies at the southern end of the rather magnificent 110km ghost-ring crater, Flamsteed P. This feature appears to have almost completely vanished below the lava that filled Procellarum.



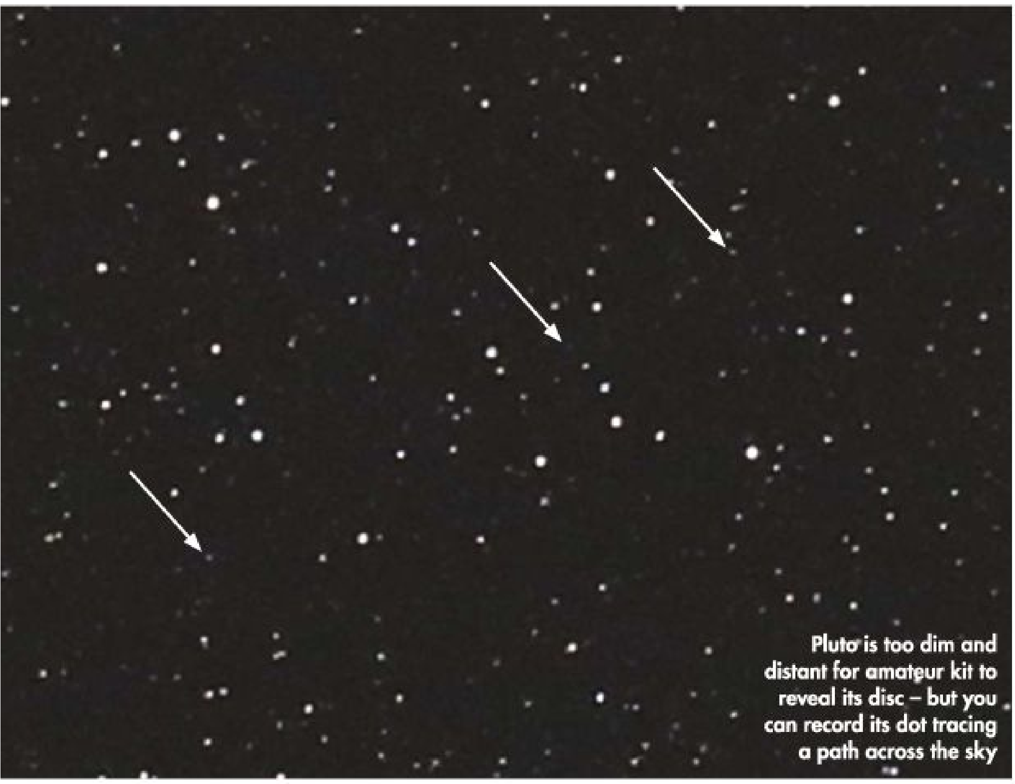
▲ Letronne has lost half its rim to Procellarum lava – a common sight in this part of the Moon

Astrophotography

Catch Pluto moving against the background sky

RECOMMENDED EQUIPMENT

DSLR camera, lens with a focal length of at least 300mm, sturdy tripod



Pluto is too dim and distant for amateur kit to reveal its disc – but you can record its dot tracing a path across the sky

PLUTO HAS ALWAYS been an enigmatic world. Once the most distant planet in our Solar System, it has now been demoted to a class of objects known as dwarf planets. Even so, thanks to the amazing success of the New Horizons mission we know just how incredible this dim and distant body actually is. Despite its rather faint mag. +14.1 brightness, Pluto is surprisingly straightforward to image. Shots of the dwarf planet's disc are beyond amateur kit, but it is still pleasing to say that you have caught it on camera.

Perhaps it is the fact that Pluto is currently located against the backdrop of the Milky Way, a multitude of faint point sources, that puts would-be Pluto hunters off. Or it could be that it has been drummed into us for so long that it's a very remote and dim object – who knows?

Pluto comes to opposition on 7 July. The closer a planet's orbit is to that of Earth's, the more dramatic a transition its globe will undergo when in the opposite part of the sky to the Sun. So Mars, for example, undergoes a striking brightening and, for a short time at least, a welcome increase in apparent diameter. Pluto is so far away that opposition doesn't really make a huge difference in its appearance, but at least it does mean that it's in dark sky.

ALL PICTURES: PETE LAWRENCE

But first you must find it

Before we even think about trying to capture it with a camera, we first need to know where to look. Being in a low part of the sky, rich in faint stars, this can be a little daunting at first. The main pattern to look out for is the asterism known as the Teapot, which is part of Sagittarius. Once identified, this will stay with you forever but it may take a few goes before you see it properly.

Once you've got the Teapot, look northeast of the handle to a faint but fairly easy to spot pattern known as the Teaspoon. The handle is orientated northeast to southwest, eventually ending with a small curved pattern of stars that represents the spoon's bowl. The mag. +2.9 star where the bowl joins the handle is called Pi (π) Sagittarii and this is our guide. Pluto starts the month very close to Pi and then moves a small distance (less than 50 arcminutes) inside the bowl. A DSLR with a reasonably modest lens of 300mm or longer focal length will be able to capture this region.

Using a medium to high ISO should allow you to go deep enough into the star field to record Pluto's dot. Unless you're using a telescope, a camera lens will probably cover an area of sky much larger than you need. However, this isn't a problem as long as the stars are relatively sharp and the noise levels are kept low.

Once you've taken your first successful shot of the region, the next task is to take another, at least a day later. Once you've done this, if everything has gone to plan, it should then be possible to blink between the images to reveal Pluto. There's a bit more to it than this, of course, but follow our guide opposite and you should be able to grab yourself a picture of this amazing world.

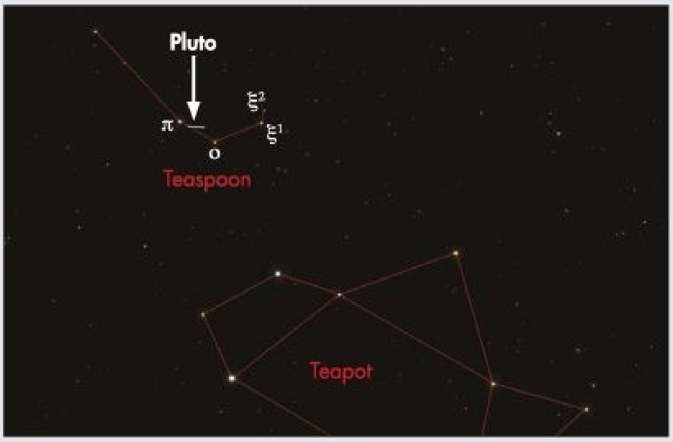
KEY TECHNIQUE

BLINK COMPARISONS

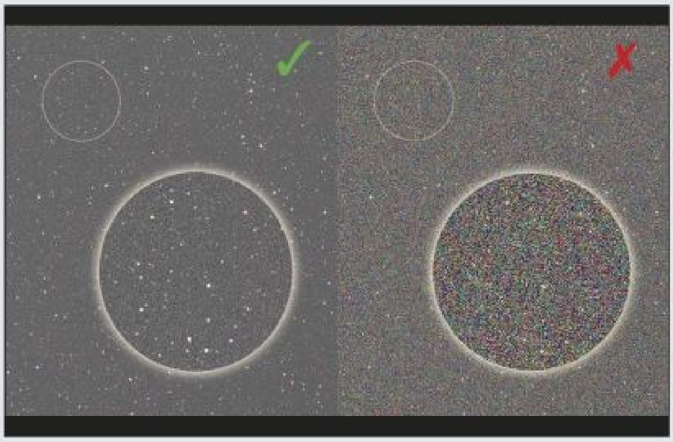
Mention Pluto and the word 'faint' probably comes to mind. Being around mag. +14.0, this is quite justified. However, it doesn't mean that Pluto's impossible to image. The trick is to use a blink-comparison technique to reveal the movement of Pluto over several nights rather than to take one single image of it. This is made more complicated by Pluto's location in Sagittarius and within the boundary of the Milky Way.

✉ **Send your image to: hotshots@skyatnightmagazine.com**

STEP-BY-STEP GUIDE



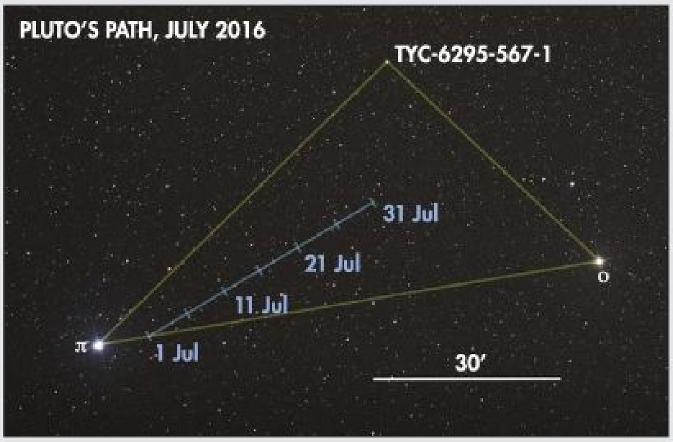
STEP 1 A lens with a focal length of 300mm or longer is ideal, but shorter ones are fine as long as they deliver sharp stars. Identify Pi (π) Sagittarii within the Teaspoon asterism in Sagittarius. If your lens is less than 800mm focal length, centre this star in the frame. Between 800-1,300mm, position Pi close to the frame's northeast corner.



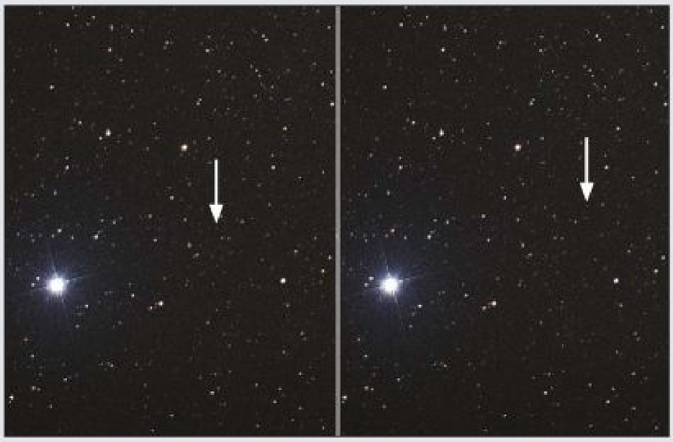
STEP 2 Although exposures will be relatively short, a driven mount will help immensely, keeping the stars sharp and helping to increase the magnitude limit your camera will be able to get down to. If you don't have one, it's worth having a go with a high ISO and keeping the exposure time to below 15-20 seconds. Watch out for noise though.

STEP 3 Accurate focus is important so take your time over it; check it by taking a test shot and reviewing at high magnification. Focusing on a bright star using the live view will achieve adequate focus, but programs such as the commercially available Backyard EOS will help you refine it even more. If the focus is even a little off, Pluto may not be identifiable.

STEP 4 A high ISO allows you to keep exposures relatively short, but make sure you're not getting too much noise as a result. A wide open lens (lowest f-number) will collect as much light as possible, but may introduce aberrations at the frame edge. Placing Pluto in the centre of the field will help overcome this. Try 30 seconds at ISO 3200-6400 with the lens set at f/3.5 or faster to start.



STEP 5 Identify the indicated triangular pattern to close in on Pluto's position. If your field is wide, you will need to zoom in to actual size or slightly larger to get a clear view of where Pluto should be. Take further shots on the next clear nights, using the same settings. Load the results in a layer-based editor and carefully align the stars between layers.



STEP 6 Keep the bottom layer visible. Hide all other layers except one. Toggle its visibility off and on, nudging it until there is no movement in the main stars. Anything else should be either noise or Pluto. Repeat with another upper layer. If the dot moves at a regular speed along the predicted track it's likely to be Pluto. Be aware that the dot may be very faint.

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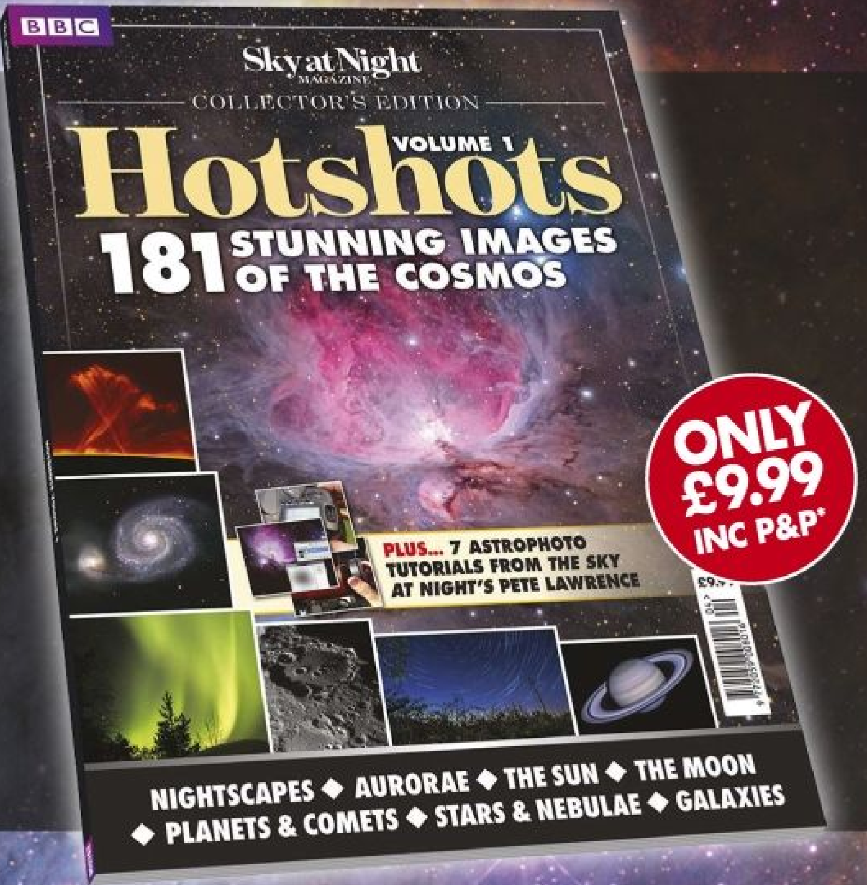
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Ferguson was a prolific astronomy populariser who toured around the country

▼ A planetarium by James Ferguson, based on the Copernican system

James Ferguson (1710-1776)

Writer, performer, instrument maker and populariser of astronomy

James Ferguson was from a lower class family in Scotland. He had barely any formal schooling, though his father could read and taught his sons. As a child Ferguson would build things, trying to make his own machines and instruments. In 1743 he moved to London and established himself as an instrument maker, globe maker, writer and lecturer. In 1763 he became a fellow of the Royal Society. His instruments were highly prized, and he advertised them through his public lectures, which he toured around the country. These lectures were turned into books, adding to his income and reputation.

Forgotten astronomers

Behind the familiar names we know all too well are many whose achievements have been overlooked, understated or forgotten. **Emily Winterburn** relates 10 of their stories

While it is the likes of Galileo, Newton and Herschel who get much of the attention, the full history of astronomy has many more characters. Often they were forgotten because of who they were, rather than what they did. Some, like Maria Winckelmann or Mae Jemison – whose stories we'll delve into in the pages that follow – were the wrong sex; some were from the wrong country, while others worked out of the spotlight, as assistants or instrument makers. Rediscovering their tales shows how, for all the brilliance of isolated genius, it has taken much more to transform our understanding of the Universe. ▸

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Comet Hale-Bopp, with its distinctive double tail, was visible to the naked eye for 18 months

Thomas Bopp (1949-present)

Modern day amateur, best known for co-discovering comet Hale-Bopp in 1995

Thomas Bopp was born in Denver, Colorado, in 1949 and later moved to Youngstown, Ohio, where he went to high school and university. In Youngstown he discovered astronomy through the local astronomical society and would observe using its 16-inch reflecting telescope. In 1980 he relocated to Tucson, Arizona, and in 1995 discovered (at the same time as Alan Hale) a new comet using a telescope he borrowed from a friend. He and Hale made their announcements to the Central Bureau of Astronomical Telegrams, who confirmed this was a new discovery. It was named after them both.

◄ Janet Taylor won medals from the kings of Prussia and Holland in recognition of her work

> **"ALTHOUGH TEACHING WAS A FAIRLY WELL-ESTABLISHED CAREER FOR A WOMAN IN THE 19TH CENTURY SUCH AS JANET TAYLOR, IT WAS MUCH LESS COMMON TO FIND WOMEN MAKING THEIR OWN SCIENTIFIC INSTRUMENTS"**

Janet Taylor (1804-1870)

Astronomer, teacher, and instrument maker for mariners

Janet Taylor (born Janet Ionn) published extensively on both astronomy and navigation and ran a successful academy which was used by the East India Company and the Admiralty. She was also an instrument maker, and ran a warehouse producing, distributing and repairing navigational instruments. Although teaching was a well-established career for a woman in the 19th century, it was much less common to find women making their own scientific instruments. And Taylor not only made instruments: she designed new ones. In 1834 she patented a design for a mariner's calculator. She was awarded a Civil List pension in 1860 for her work in navigation.

Caroline Moore (1994-present)

A young woman who discovered a rare supernova at the age of 14

Caroline Moore was 10 years old when she was given a telescope for Christmas. From there she joined a local astronomy society with her father and went on to join the Puckett Observatory Supernova Search Team as a data searcher. Caroline's job was to study old and new pictures of the same piece of sky and look for differences. In 2008 she spotted a very faint difference she couldn't find reference to anywhere else. That difference was the supernova SN 2008ha.

▲ Caroline Moore (left) with her telescope and the supernova she discovered (right) in Pegasus

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▲ Founded in 1257, the Sorbonne didn't have a female professor until 1789

Louise du Pierry (1746-date unknown)

Hero of Caroline Herschel, student of Jérôme de Lalande, and the first female professor at the Sorbonne

Louise du Pierry was a student of Jérôme de Lalande in 1779; 10 years later she became the first female professor at the Sorbonne in Paris. There she introduced a course in astronomy aimed (for the first time) at female students. Her research was mainly in positional astronomy: she predicted eclipses and calculated tables of the length of day and night; she also assembled refraction tables. Lalande, in his 1785 book *Astronomie des Dames* described her as a role model for other women because of her intellectual abilities. Caroline Herschel called her a "fortunate rival" due to her superior knowledge of calculus.

▲ Lunar crater Blagg is 5.4km across and located on the Sinus Medii at 1.3°N, 1.5°E

Mary Adela Blagg (1858-1944)

Among the first women to be elected Fellow of the Royal Astronomical Society

Mary Blagg was from Cheadle in Staffordshire and lived there her whole life. She taught herself mathematics by reading her brother's textbooks and later enrolled in a course – taught by John Herschel's grandson, Mr J A Hardcastle – which ignited her interest in astronomy. Her main field of research was the Moon (there is a crater named after her) and she published catalogues of lunar formations, working out of the lunar section of the International Astronomical Union. Blagg worked on variable stars too and for that work was elected – alongside four other women – a Fellow of the Royal Astronomical Society in 1916. ►

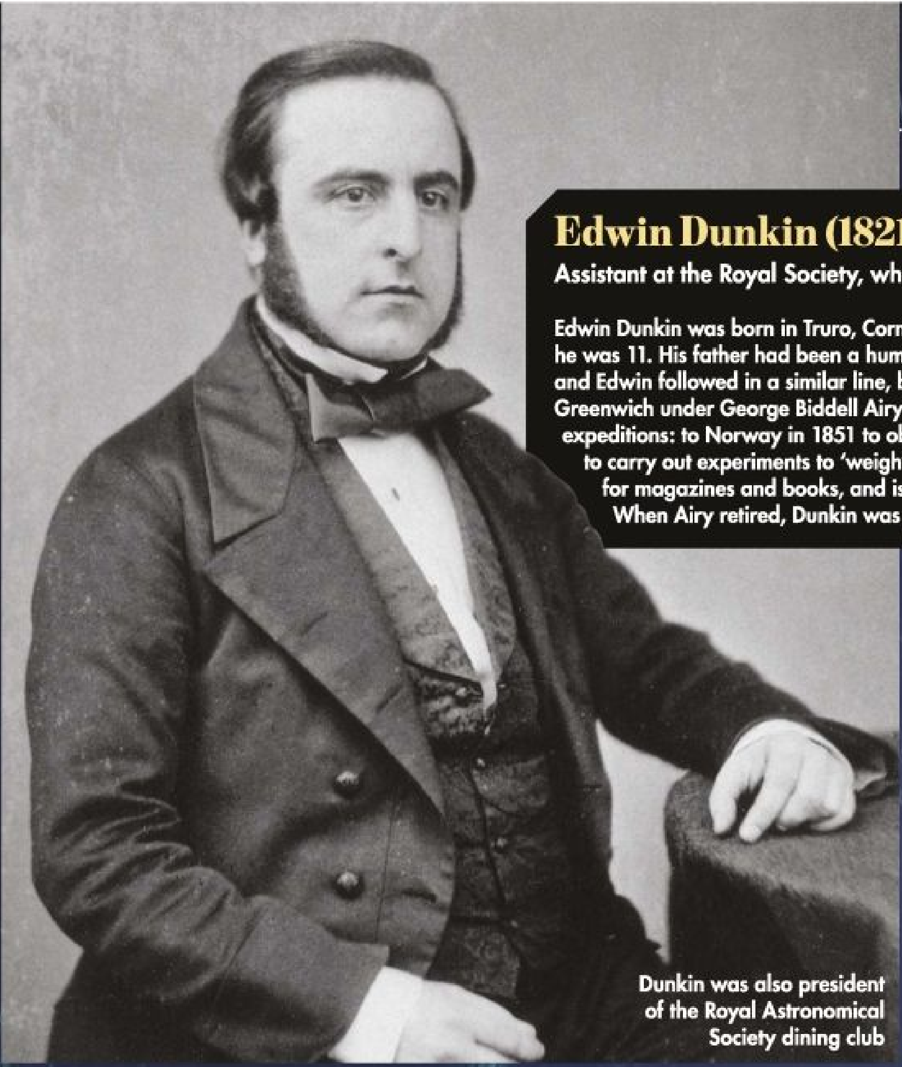
> **"JEROME DE LALANDE DESCRIBED LOUISE DU PIERRY AS A ROLE MODEL FOR OTHER WOMEN BECAUSE OF HER INTELLECTUAL ABILITIES. CAROLINE HERSCHEL CALLED HER A 'FORTUNATE RIVAL' DUE TO HER SUPERIOR KNOWLEDGE OF CALCULUS"**

Mae Jemison (1956-present)

The first African-American woman in space could have chosen dancing

Mae Jamison could not decide between a career in dance or medicine. On her mother's advice, she decided on medicine, with dance as a hobby. First however, she went to Stanford University aged just 16, graduating in chemical engineering. After that she went to medical school and then onto the Peace Corps. In 1983 she applied for NASA's astronaut programme and in 1992 joined the crew on the Space Shuttle Endeavour, living in space for eight days, carrying out experiments on weightlessness and motion sickness. In 1993 she resigned from NASA to set up her own technology business. Currently she lectures, campaigns and runs businesses and a foundation.

Mae Jemison aboard Space Shuttle Endeavour in September 1992



Edwin Dunkin (1821-1898)

Assistant at the Royal Society, who helped on some famous projects

Edwin Dunkin was born in Truro, Cornwall, but left for London with his family when he was 11. His father had been a human computer for the British Nautical Almanac, and Edwin followed in a similar line, becoming an assistant at the Royal Observatory Greenwich under George Biddell Airy. While at Greenwich he was sent on expeditions: to Norway in 1851 to observe an eclipse; to a colliery in South Shields to carry out experiments to 'weigh' the Earth. He popularised astronomy writing for magazines and books, and is best known for his book *The Midnight Sky*. When Airy retired, Dunkin was promoted to Deputy Astronomer Royal.

Dunkin was also president of the Royal Astronomical Society dining club

> "MARIA WINCKELMANN ASSUMED SHE WOULD TAKE OVER HER HUSBAND'S ROLE WHEN HE DIED. THE ACADEMY COUNCIL, HOWEVER, RULED AGAINST IT"

The institution that snubbed Winckelmann no longer exists; it has been replaced with the Berlin-Brandenburg Academy of Sciences and Humanities

Maria Winckelmann (1670-1720)

Denied the role of astronomer at Royal Academy of Science in Berlin

Maria Winckelmann was taught first by her father, then by her uncle and then by an astronomer and farmer near Leipzig, Christoph Arnold. Through Arnold she met and later married the astronomer Gottfried Kirch, 30 years her senior, who was well established as astronomer and calendar maker at the Royal Academy of Science, Berlin. He helped her continue her education and soon they were collaborating on observations, calculations and the production of calendars and almanacs. In 1710 Gottfried died, and Maria assumed she would take over his role. The academy council however ruled against it because of her sex, and the post was given to the relatively inexperienced Johann Heinrich Hoffmann instead.

▲ When not contemplating the stars, Vincent Wing worked as a land surveyor

Vincent Wing (1619-1668)

Astronomer, astrologer and surveyor from a family of astronomers

Vincent Wing was an astronomer in the 17th century – just before astronomy and astrology parted ways. He wrote and compiled tables in both astronomy and surveying. An annotated copy of one of his books was found in Isaac Newton's library; another, his ephemerides for 1652-1671, was described by John Flamsteed as the most accurate of its time. At the same time, Wing also cast horoscopes and in 1660 edited a defence of astrology, stating that "the stars incline the will" and that "astrologers fore-tell truths". Ⓢ

BBC RADIO 4 extra Astronomer Heather Couper charts the history of our growing understanding of the stars in Cosmic Quest. Listen here: http://www.bbc.co.uk/programmes/b00bs1zf/episodes/guide

ABOUT THE WRITER

Emily Winterburn is a historian of astronomy, museum curator and the author of *The Stargazer's Guide: How to read our night sky*

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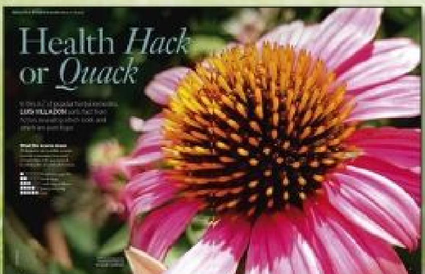

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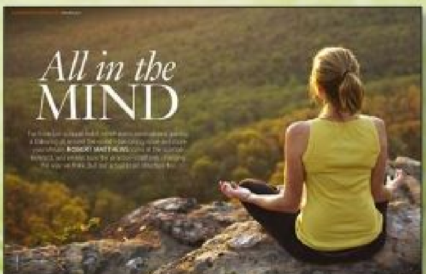

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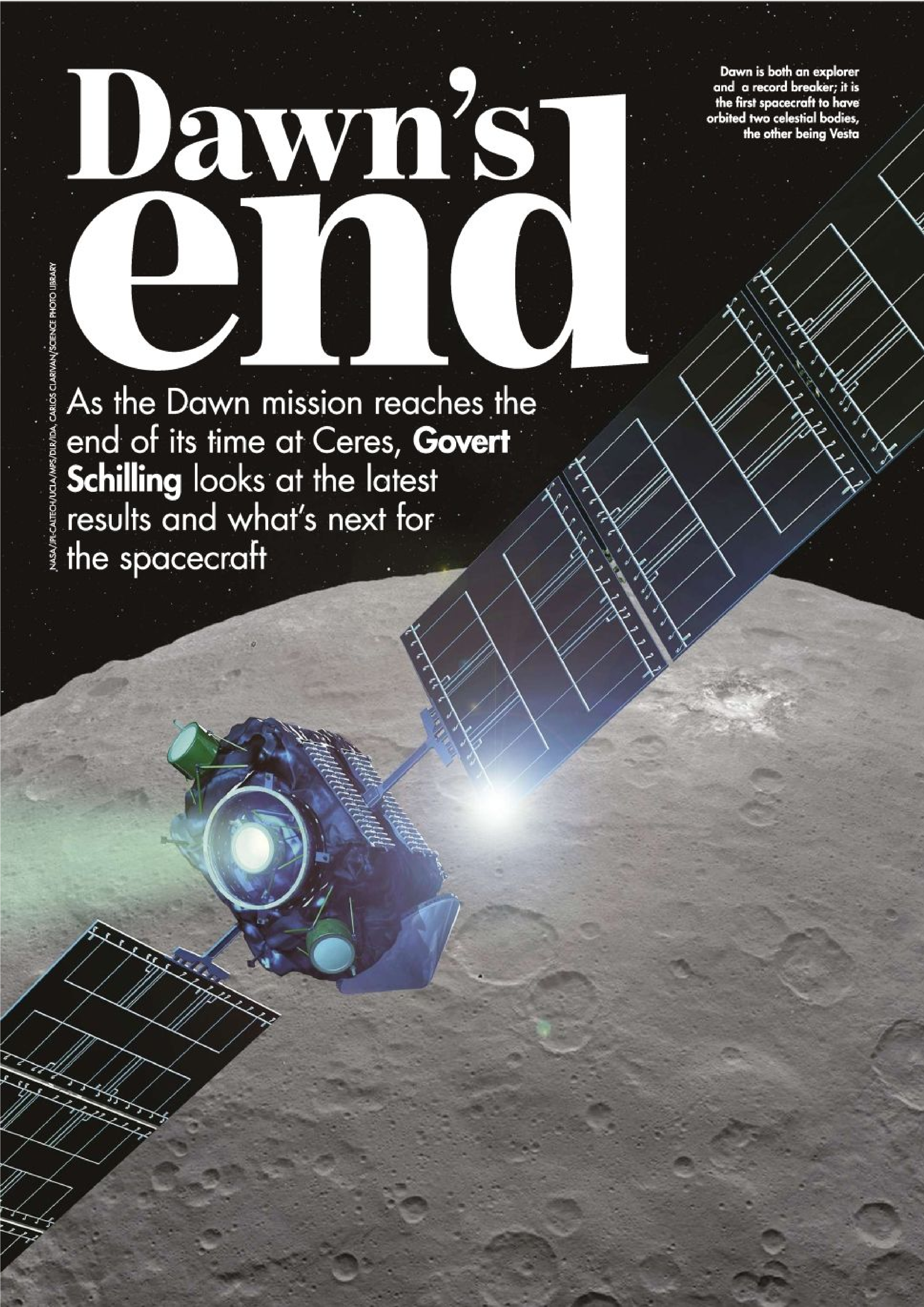
Dawn's end

As the Dawn mission reaches the end of its time at Ceres, **Govert Schilling** looks at the latest results and what's next for the spacecraft



Dawn is both an explorer and a record breaker; it is the first spacecraft to have orbited two celestial bodies, the other being Vesta

NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA, CARLOS CLARIVAN/SCIENCE PHOTO LIBRARY

This summer, NASA's Dawn spacecraft officially ends its investigation of dwarf planet Ceres, the largest body in the asteroid belt . Planetary researchers are now trying to make sense of all of the data it has since returned.

Dawn's principal investigator, Chris Russell of the University of California at Los Angeles, must feel like a 21st-century Christopher Columbus. His tiny spacecraft, powered by a revolutionary ion engine, arrived at the minor planet Vesta in 2011, leaving for Ceres in 2012. It arrived there in March 2015, and for fifteen months, its three instruments have studied the dwarf planet in minute detail, eventually from an altitude of just 375km.

But in mid-April, at a special Ceres session during the 2016 General Assembly of the European Geosciences Union in Vienna, Austria, it became clear that Ceres has not yet yielded all of its mysteries. To the contrary: Dawn's observations may have raised more questions than it has answered. Let's take a look at some of them.

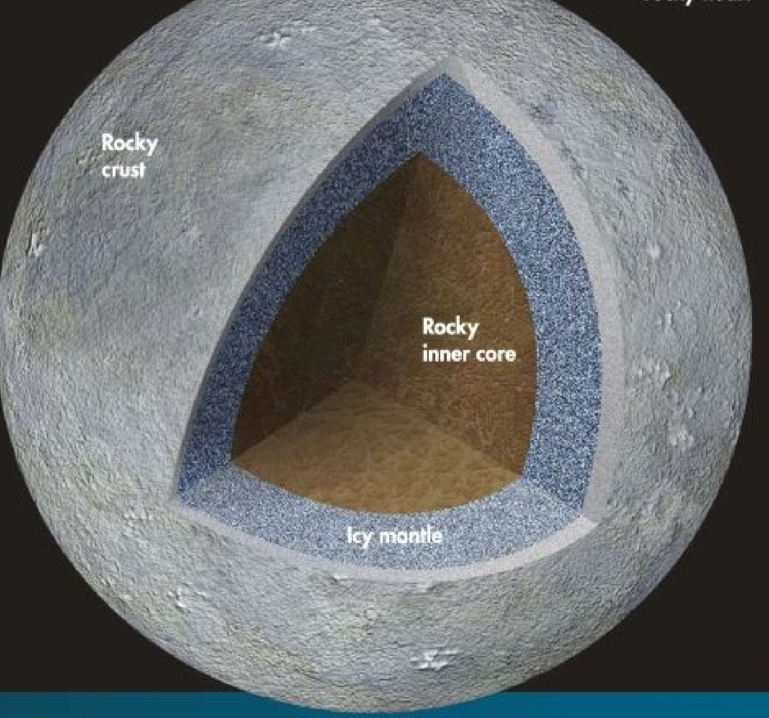
WHAT KIND OF WORLD IS CERES?

Contrary to Vesta, which is a high-density body with an iron core and a rocky mantle, Ceres has a relatively low density of just 2.16g/cm^3, indicating a large amount of icy material. Surprisingly, however, it has quite a bit of vertical relief (some 7km), indicating a rocky crust. Moreover, Ceres's interior is much more homogeneous than Vesta's, and it lacks an iron core.

Michelangelo Formisano of the National Institute of Astrophysics in Rome, Italy, now

▲ Ceres has relatively few large impact craters, suggesting its surface is young

▼ Unlike Vesta, Ceres is theorised to have a rocky heart



NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA X 8, NASA/ESA/STSCI, NASA/JPL-CALTECH/UCLA/MPS/DLR/ IDA/PSI/LPI X 2, NASA/SANDRA, JOSEPH AND RAFAEL HERNANDEZ, ISTOCK, NASA/JPL-CALTECH

DAWN MISSION **TIMELINE**

The Dawn spacecraft has broken records since launch in 2007

SEPTEMBER 2007
Dawn is launched with a Delta II rocket from Cape Canaveral in Florida, US

FEBRUARY 2009
Dawn flies by Mars for a gravity assist, setting the spacecraft on its course to Vesta

JULY 2011
Dawn enters orbit around Vesta, the second-largest body in the asteroid belt

SEPTEMBER 2012
Dawn uses its ion engine to leave Vesta and sets a course for its second target

MARCH 2015
Dawn reaches Ceres and becomes the first probe to orbit two bodies beyond Earth

believes that Ceres has a large silicate core with a radius of 370km, surrounded by a mantle of ice or icy mud with a thickness of 90-100km. On top of that is a rocky crust between 1km and 10km thick.

Really large impact craters on Ceres are rare, and crater counts suggest that large swaths of its surface are relatively young, suggesting some form of resurfacing. All in all, Ceres is very different from Vesta, suggesting a different origin and evolutionary history.

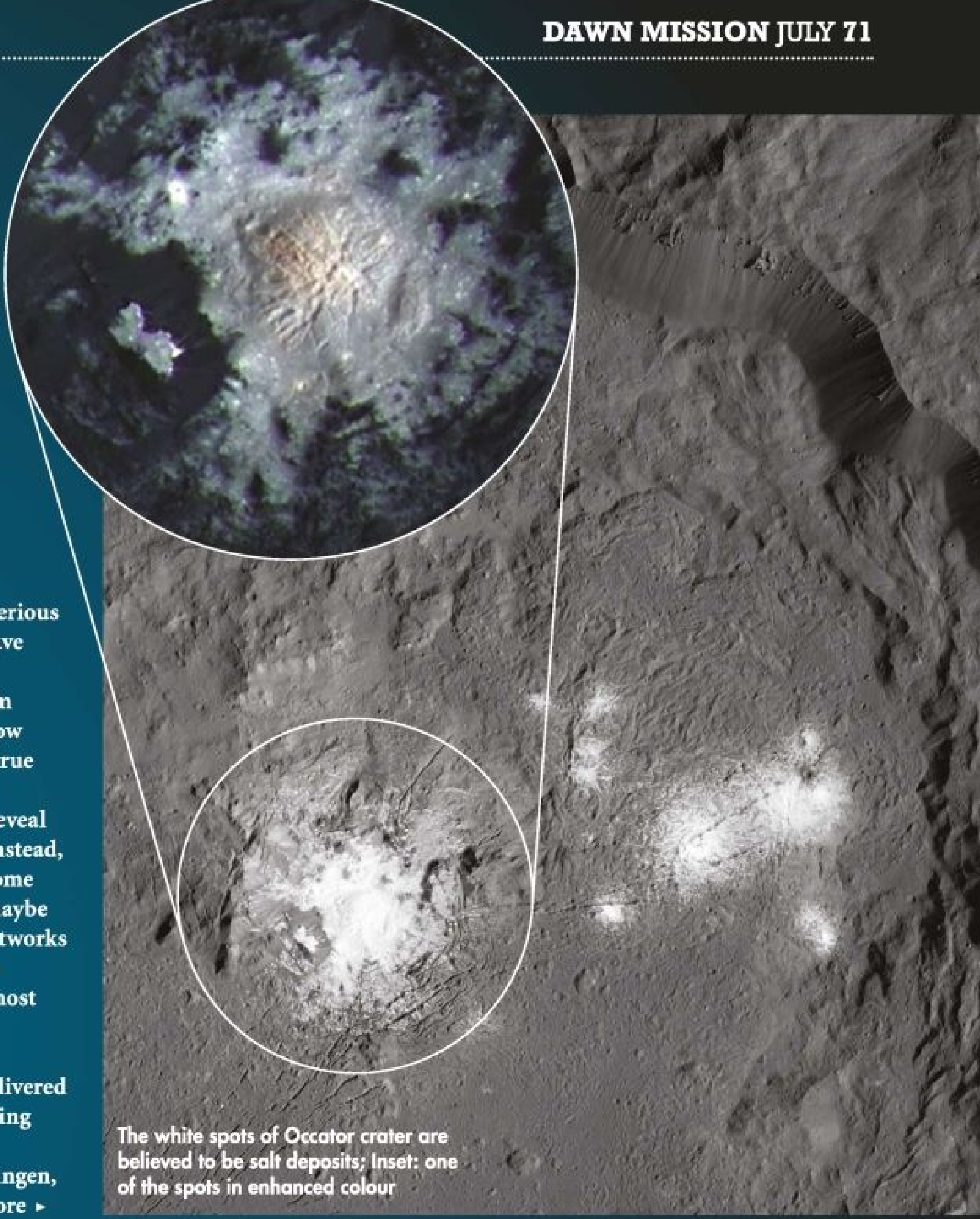
WHAT ARE CERES'S BRIGHT SPOTS?

Ever since they were discovered by Dawn, during its slow approach of Ceres, the mysterious white spots on the dwarf planet's surface have grabbed everyone's attention.

The brightest ones are located in the 92km crater Occator, but over 130 of them have now been found all over the surface. Still, their true nature eludes scientists.

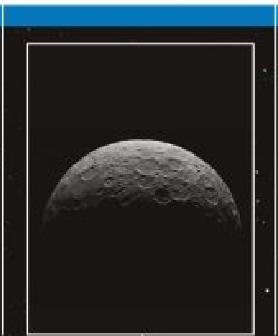
Measurements by Dawn's spectrometer reveal that the bright spots do not consist of ice. Instead, they appear to be mineral salt deposits of some sort, containing chlorides, sulphides and maybe carbonates. They're also associated with networks of cracks and flow-like structures, and with bluish, younger surface areas. In Occator, most of the bright material sits on top of a huge dome-shaped mountain.

All of this suggests that salts are being delivered to the surface from below, maybe by upwelling brines. Michael Schäfer of the Max Planck Institute for Solar System Research in Göttingen, Germany, also identified over a hundred more ▸

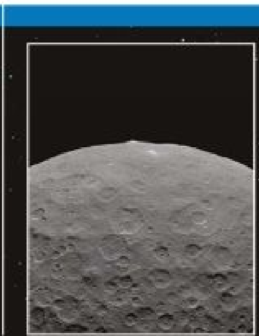


The white spots of Occator crater are believed to be salt deposits; Inset: one of the spots in enhanced colour

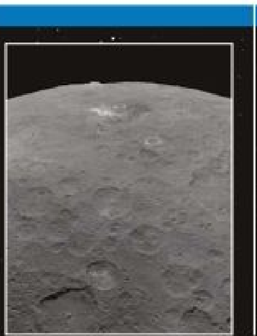
APRIL 2015
Science operations begin. Dawn is in its RC3 orbit (13,500km altitude, 15-day period)



JUNE 2015
Dawn starts to observe from its survey orbit (4,400km, 1.3-day period)

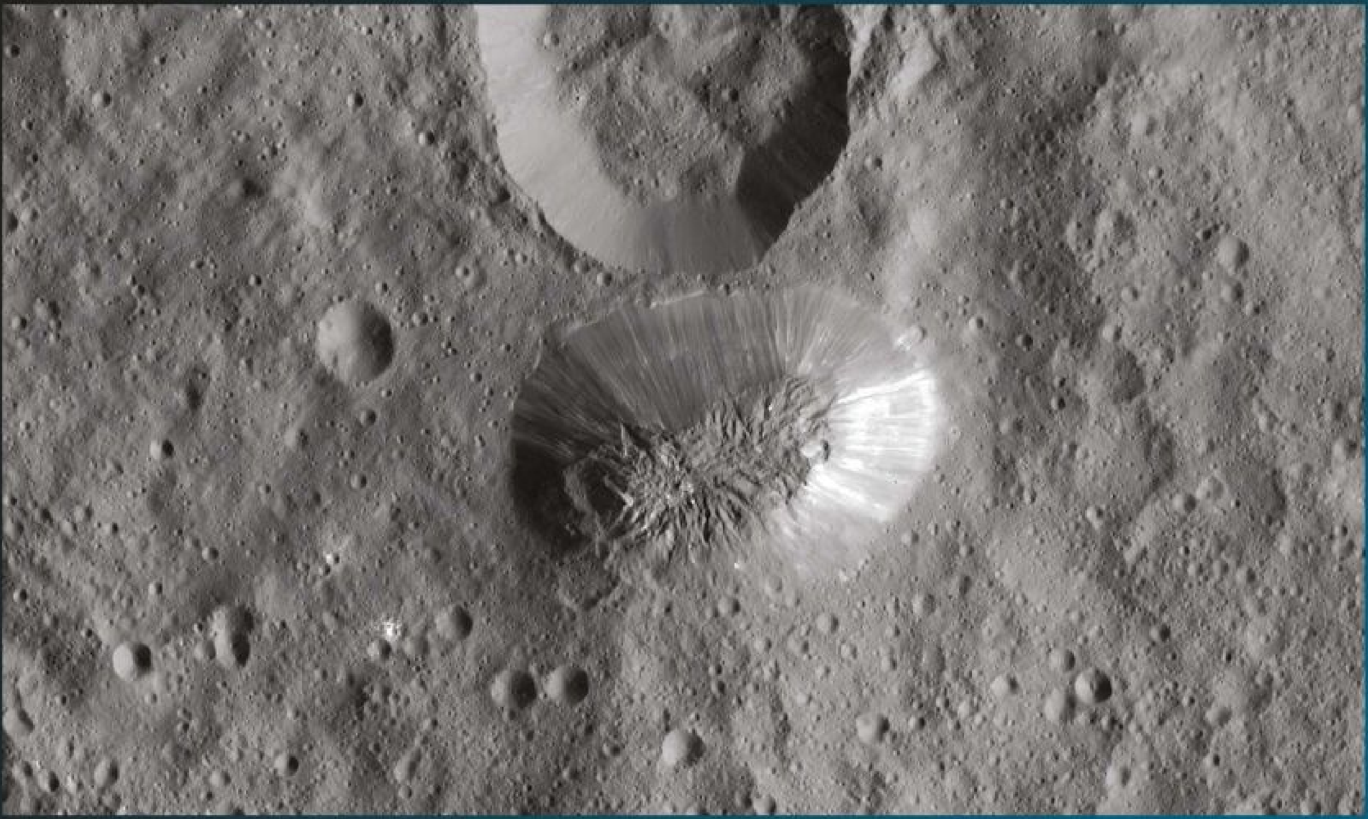


AUGUST 2015
Dawn enters its high-altitude mapping orbit (1,450km, 19-hour period)



DECEMBER 2015
Dawn ends up in its low-altitude mapping orbit (375km, 5.5-hour period)

JUNE 2016
Official end of the Dawn mission; but perhaps not the end for the probe itself



▲ Ahuna Mons is a mystery mountain, standing alone amidst otherwise smooth terrain

▸ yellowish spots (most of them in and around crater Dantu), which is indicative of sulphur-bearing material.

IS CERES STILL ACTIVE TODAY?

The upwelling of bright material in Occator and other craters may have been caused by the heat of the impact that formed the craters in the first place. But Schäfer's colleague Martin Hoffmann is one of the scientists who believes that Ceres is still geologically active today. "There's lots of evidence of recent hydrothermal venting," he says.

Last year, ESA's Herschel Space Observatory discovered water vapour being released from the surface of Ceres – isn't that a clear indication of ongoing activity? Not necessarily, says Carol Raymond of NASA's Jet Propulsion Laboratory in Pasadena, California, who is Dawn's deputy principal investigator. "It's just a very small amount – some 6kg per second," she says, "and probably due to seasonal sublimation of small amounts of surface ice."

Then again, it's obvious that Ceres hasn't been an inert world since the birth of the Solar System. According to Roland Wagner of the German Aerospace Center DLR, who presented the first detailed geological maps of Ceres at the European Geosciences Union meeting, the dwarf planet's geology "appears to [have been] compressed in the last one or two billion years". The mysterious, artificial-looking Ahuna Mons may be no older than a few million years. "We're probably looking at a young, active body," says Wagner.

DOES CERES HAVE A SUBSURFACE OCEAN?

"Not at present," says Raymond, "but all the evidence suggests there has been an underground ocean for the first two billion years or so after its formation," thanks to heat generated by the accretion of smaller planetesimals and radioactive decay. When the ocean slowly froze, brines were

▼ L-R: Kupalo, one of the youngest craters on Ceres; crater Hualani, which bears the marks of landslides from its rim; and the troughs and grooves surrounding the Gerber Catena crater chain

NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA X 4

CERES IN **NUMBERS**

Essential facts for Dawn's orbital home since 2015

938,416,000,000,000,000
Mass in metric tons

2,770,000
Surface area in square kilometres

434,000,000
Volume in cubic kilometres

17.9
Average orbital velocity in kilometres per second

168
Mean surface temperature in Kelvin

9.074170
Rotation period in hours

0.0758
Orbital eccentricity

445,410,000
Aphelion distance to the Sun in kilometres

382,620,000
Perihelion distance to the Sun in kilometres

473
Mean radius in kilometres

0.51
Escape velocity in kilometres per second

1801
Year of discovery (by Giuseppe Piazzi)

4
Axial tilt in degrees

10.6
Orbital inclination in degrees

4.6
Orbital period in years

0.029
Surface gravity in G

2.162
Mean density in grams per cubic centimetre

probably pushed out onto the surface, leaving the salt deposits seen today.

Scientists believe that the flow patterns that have been found in many places on Ceres were produced by this so-called 'cryomagma'. Also, there's strong evidence for clay minerals formed under the influence of water. At present, it's extremely unlikely that microorganisms could survive beneath Ceres's surface but, according to Raymond, that may have been different in the past. "We're looking at all the options," she says.

WHERE DID CERES FORM?

Ceres may be the largest object in the asteroid belt, but according to Cristina De Sanctis of the Italian National Institute of Astrophysics, it may have formed in the frigid outer parts of the Solar System – in the Kuiper Belt beyond Neptune. "It's a pretty new and unexpected idea," she says. Her main argument: the detection of widespread ammonium-bearing clay minerals by Dawn's spectrometer.

"Ammonium isn't stable at the present position of Ceres," says De Sanctis, "so either most of the planetesimals from which the dwarf planet accreted came in from the outer Solar System, or Ceres started out as a Kuiper Belt object, and then migrated to its current location. I see no other way to incorporate so much ammonium."

WHAT NEXT FOR DAWN?

After bagging so many intriguing discoveries, it's little wonder that the Dawn team has asked NASA for a mission extension beyond 30 June, the official end date. The craft may prolong its study of Ceres, or it may even fly off to yet another body in the asteroid belt. "We are seriously considering that option," Russell said at the European Geosciences Union meeting, "but for now, I'm not going to tell you which asteroid we have in mind." Ⓢ

YOUR BONUS CONTENT

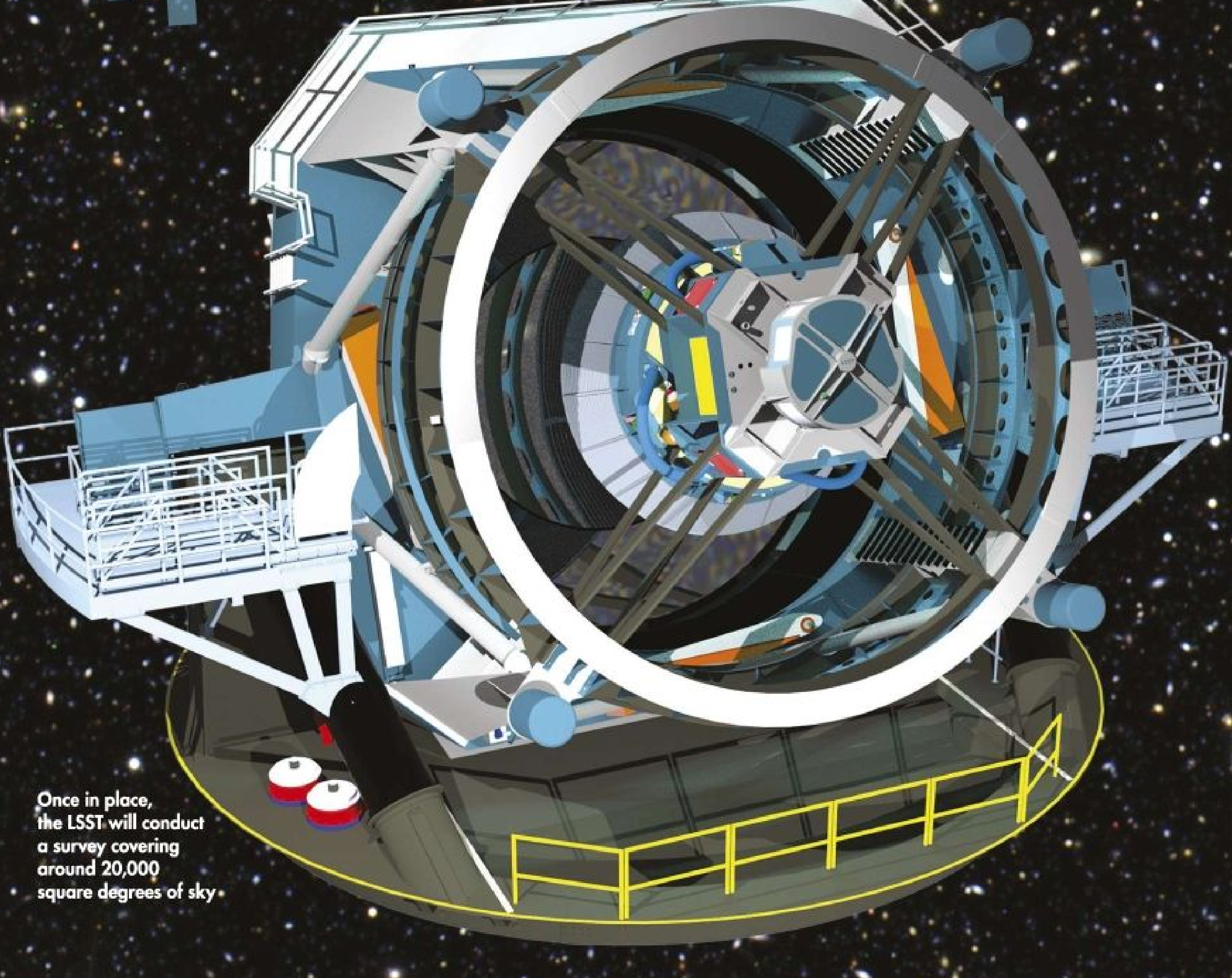
Watch animations of new Dawn mission data sent from Ceres

ABOUT THE WRITER

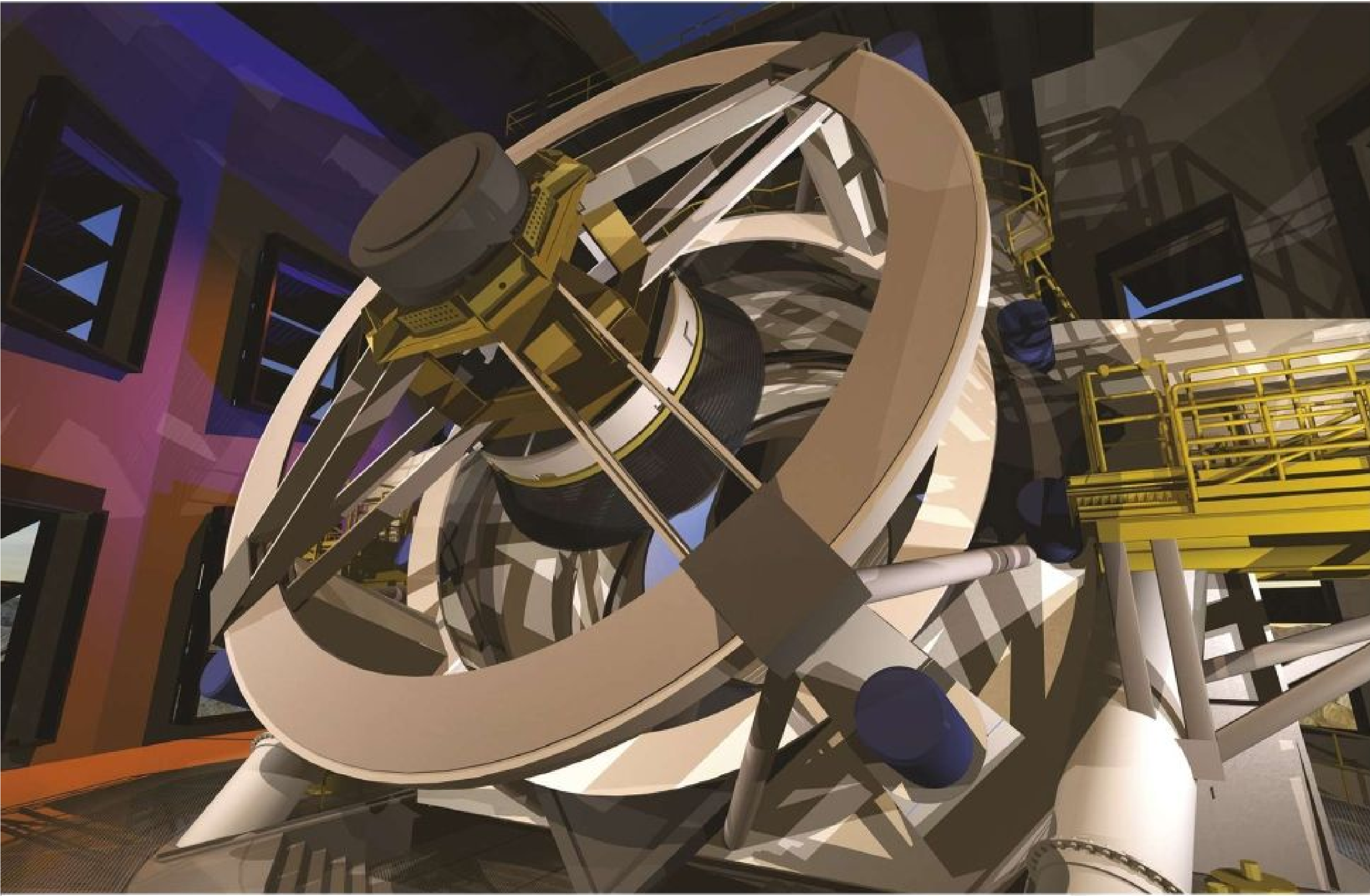
Govert Schilling is an astronomy writer and the author of *Deep Space: Beyond the Solar System to the End of the Universe and the Beginning of Time*

DIGITISING THE SKY

The Large Synoptic Survey Telescope, under construction in northern Chile, has been described as the most important telescope project on Earth. **Eagle Gamma** finds out why



Once in place, the LSST will conduct a survey covering around 20,000 square degrees of sky



▲ An artist's impression of the completed telescope

The Large Synoptic Survey Telescope (LSST) will conduct a decade-long digital survey so big that it will change the way researchers do astrophysics and reorientate amateur astronomy. The massive sky survey marks the era of the virtual observatory, and the three-dimensional video of the Universe it will produce could pave the way to primarily digital observations of the cosmos, doing away with the need for observational astronomy.

The LSST team calls this approach the 'New Sky', and claim that the project will observe more in its first month than all previous telescopes ever have, put together. With the world's largest digital camera and biggest data collection capacity, the scope will enable all kinds of research; the agenda covers everything from near-Earth asteroids to distant stars, from galaxies to cosmology.

"In a nutshell, LSST is a deep survey of the southern sky, covering about 20,000 square degrees," says LSST systems scientist Chuck Claver. "We'll do it with six spectral filters that cover the optical spectrum."

The database created from this survey will provide a library of 20 billion celestial objects. Astronomers will constantly analyse incoming data, looking for transient events – objects that change over time. Simply to convert the raw data from the hardware into useful imagery will be a huge hurdle. Hundreds of teraflops of computational power will need to kick into high gear, with around a gigabyte of data being collected per galaxy, the billion-dollar telescope will observe many billion stars and galaxies in its lifetime. Imagine the citizen science project this could lead to: every person on Earth could have their own galaxy to explore.

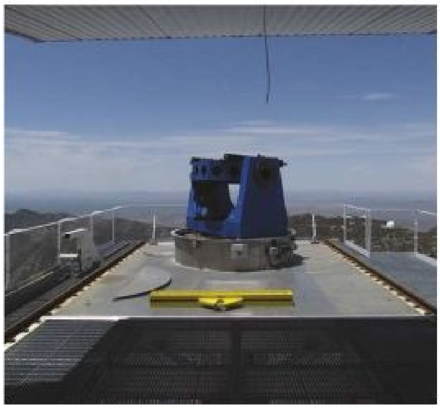
Most important project

The development of the LSST is being organised by the National Optical Astronomy Observatory (NOAO) at its headquarters in Tucson, Arizona. It conducts research with one of the planet's greatest collections of telescopes atop nearby Kitt Peak. With information processing accounting for around half of all the LSST's operational costs, the project ▸

▼ Five of the scope's six coloured filters can be mounted at once

LSST X 4, ISTOCK

▲ **Mirror surfaces for the telescope being polished and tested in 2013**


▲ **Calypso, a small (1.2m) atmospheric telescope that will sit alongside the LSST**

▲ **The Cerro Pachón location is already home to some traditional telescopes**

LSST X 6, ISTOCK X 3

► also includes facilities at the National Center for Supercomputing Applications in Illinois.

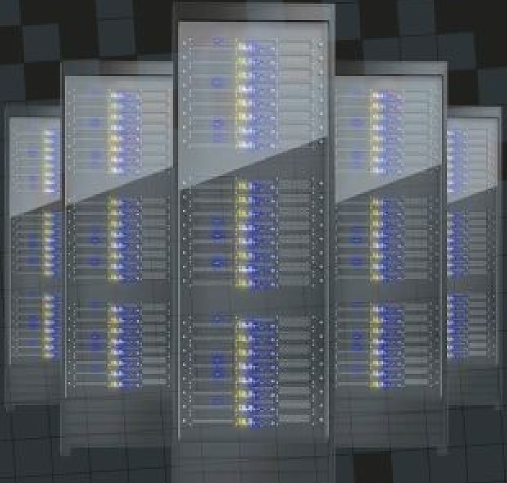
In the major decadal review, *New Worlds, New Horizons*, published in 2010, astronomers determined the LSST to be the single most important telescope project on Earth. In addition to the US Government, financial support comes from some less common sources. Software billionaires Charles Simonyi, Bill Gates and Eric Schmidt have donated tens of millions of dollars.

The facility is expected to be the first telescope capable of detecting most of the asteroids that threaten Earth – up to 90 per cent of them, pushing the detection threshold down from 1km to 140m. Exotic surprises, such as neutron stars or gamma-ray bursts, pop up a lot more often when you can cover more of the sky. We may even discover new types of celestial object altogether.

The device will look at the mysterious increasing expansion of the Universe, to reveal whether it happens uniformly in all directions. Many

A GROUNDBREAKING TELESCOPE

At the heart of the LSST are three technologies: the camera, the mirrors and the IT system



SUPER CAMERA

With a resolution of 3.2 billion pixels, equivalent to a thousand smartphones, the LSST's digital camera will be the world's largest, with a mosaic of 189 individual 16 megapixel detectors. The images it captures will have a diameter of 64cm. The physical dimensions of the device are huge: at 3x1.7m and weighing 2,800kg, the camera will be the size of a rhinoceros.

SUPER MIRROR

The f/1 telescope uses a unique composite mirror whose compact design will ease surveys. The 8.4m combination has a field of view of 10 square degrees, and will take in large chunks of sky in a thousand nightly pairs of 15-second exposures. Accumulating tens of thousands of square degrees each week, then rescanning, the telescope will cover over half of the southern sky.

SUPERCOMPUTER

The scale of data-processing needed for LSST data is unprecedented. This is largely an IT telescope, and it will be the largest data system on the planet. Every night, the telescope will generate 30 terabytes of raw data. Over a year, this totals a petabyte (one million gigabytes). After processing, the size will add up to half an exabyte– that's around a quadrillion bytes.

astrophysicists now explain this phenomenon with elusive dark energy. The survey will restrict what this can be, if it even exists; and it may instead uncover new astrophysics.

Construction has started at a dark-sky site on Cerro Pachón in northern Chile, with first engineering light in 2019 and first science light in 2021. The LSST design looks futuristic – a sleek and modern facility. And, through partners including Google, the astronomical flows of data will go around the world.

The telescope uses a unique triplicate mirror, combining primary and tertiary reflectors with a mediating secondary. The combination of mirrors has already been built in Tucson. The entire mirror was first shaped for the primary, then had the tertiary portion ground out of the middle. Sharing the same substrate, both mirrors focus together on a single field.

The composite mirror comes from the famous Steward Observatory Mirror Lab. Here, molten glass gets spun into complex forms, with a honeycomb backing that provides lightness and cooling. The pure borosilicate glass is spun at around 5RPM, then cooled from around 1,150°C over a few months to solidify.

According to Dennis Zaritsky, deputy director of the Steward Observatory Mirror Lab, the mirror shares its genealogy with other top telescopes, including the Large Binocular Telescope and the Giant Magellan Telescope. "All of our mirrors are built to give you images as good as the atmosphere will allow you to get," he says. The triplicate mirrors are a key enabler for this massive survey. "To get the big field of view the design is very different from any other telescope."

A scope like no other

The immense volume of data being collected from the LSST will change the investigative enterprise of astronomy from one of managing optics to one of analysing data. After the LSST's huge survey, it will be easier to study stars online in a virtual observatory instead of through physical instrumentation.

Figuring out the optimal space and time sampling of the sky poses a major challenge, though. "That is the fundamental currency of the LSST," says Victor Krabbendam, the telescope's project manager.

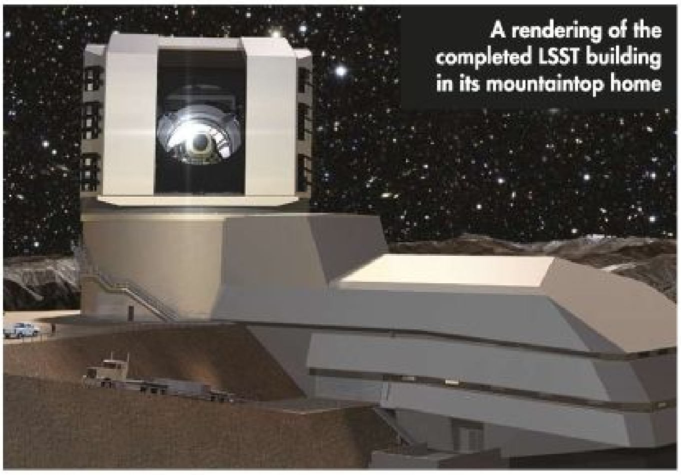
With an average view out to magnitude +24.0, the telescope can focus all the way out to mag. +28.0 – a hundred million times fainter than the human eye can see. This takes the view back to redshift three, to a time when the Universe was around 15 per cent of its present age. "It's deeper, it's wider, and it's faster," says Krabbendam.

Over 5,000 professional astrophysicists will produce research on the basis of the LSST's data set. Citizen scientists will also perform essential investigations, and in doing so the telescope will make the dream of an interactive software version of the Universe into a reality.

And, in recording the evolution of the Universe over a decade, the LSST will make the biggest home movie of all. "The systematic exploration of the time domain across such a large part of the sky has never been done before," says Claver. Zaritsky is equally optimistic: "Every field of astronomy will be advanced," he says. "I think the real revolution in this is the transient Universe."

To get a feel for what the telescope will see, first imagine taking a photo of the Moon. Then, expand the view to a grid the size of seven Moons by seven Moons. Put on 3D goggles, and imagine that you can see thousands of times better than high-definition cameras. Then, watch the sky like this for 10 years.

The LSST is uniting the best of current technology to create a three-dimensional movie of the Universe for everyone to investigate. With it, a digital astronomy revolution is underway.



A rendering of the completed LSST building in its mountaintop home

LARGE SCALE CITIZEN SCIENCE

It's not just professional astronomy the LSST will affect: everyone will have access to the data

LSST data is going to be shared publicly. Alerts from the entire database will become available almost instantaneously, and annual reports will include its entire catalogue. To start, only formal partners will receive the full raw data, in addition to the public processed data. However, a primary goal of the project is to make the overall results available to everyone, notably in the form of an interactive video of the Universe. Improvements to space models like Google Sky and Microsoft's WorldWide Telescope, along with data in simpler formats, will share the astronomy with everyone. The new survey hardware and software promise to kickstart a new age of the fully fledged citizen astronomy.

Take one example: astrophysicists currently know of about 500 gravitational lenses. With the immense repository of LSST data, tens or hundreds of thousands more could be discovered. It will take the time and acuity of citizen scientists to identify them, however: the telescope will produce far too much data for any one observer to deal with.

Going several orders of magnitude deeper than existing surveys, the higher level of information will serve the public a look into our place in the cosmos. The public education portion of the mission is intrinsic to the project – on an equal footing with professional and amateur astronomy research. "I want the telescope to reach out to the classroom, to interested people at home, to lifelong learners," says Victor Krabbendam, the telescope's project manager.

ABOUT THE WRITER

Eagle Gamma is a writer specialising in astronomy and astrophysics. He is writing a book, *Astrotripping: A Cosmic Joyride.*

SKILLS Brush up on your astronomy prowess with our team of experts

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81 HOW TO
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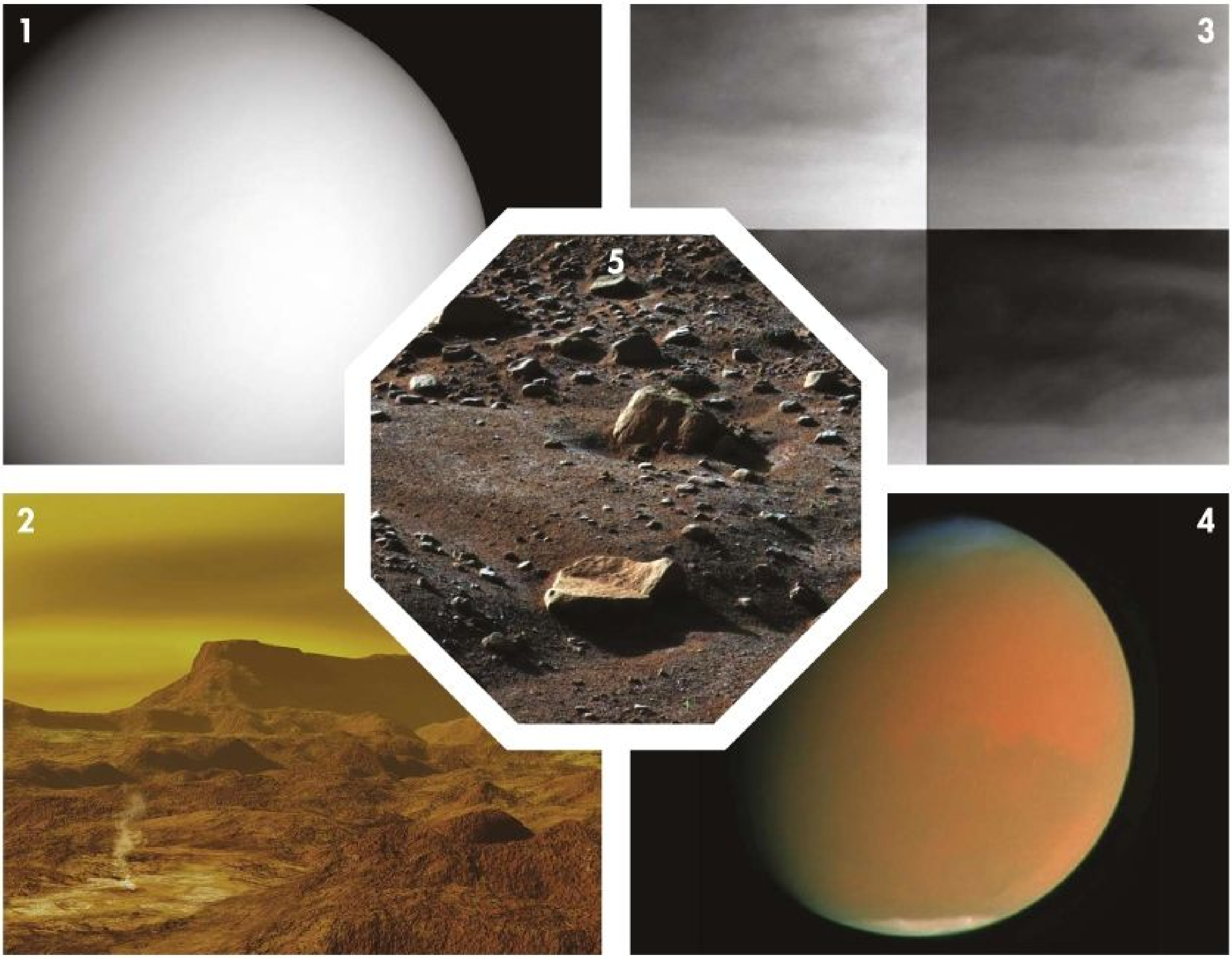
87 SCOPE DOCTOR

The Guide

Weather in the Solar System

With **Chris Bramley**

You'd need more than a coat to brave the elements on other planets



▲ **[1] NASA's Messenger probe was greeted by a thick, featureless cloud layer when it passed Venus [2] But underneath lies a fierce world in line with the classical vision of hell [3] Among the Phoenix lander's many discoveries were clouds of dust and ice in the Martian atmosphere above it [4] Sometimes Mars is completely covered by violent sandstorms [5] Phoenix also found frost in its immediate vicinity near Mars's north pole**

Over the past few years extreme weather events on Earth have risen: heatwaves, downpours, hurricanes and droughts beyond the bounds of normal weather patterns have all broken records. These unusual occurrences are what Earth's climate produces as it experiences a period of change.

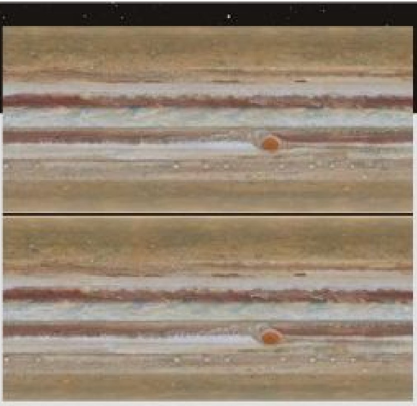
For there to be weather in the first place there needs to be some kind of atmosphere and a source of energy to cause changes in that atmosphere. Here on planet Earth, the Sun heats our atmosphere, causing temperature differences that create air currents, which bring wind and also (along with other processes) rain. So a planet without an atmosphere would have no weather and that's exactly the case on Mercury. While it is scorchingly hot on its Sun-facing side, reaching highs of 430°C, there's nothing to preserve that heat when the Sun goes below the horizon, and so Mercury's night side experiences temperatures as low as –180°C. There's no wind, no cloud and certainly no rain; it's all very monotonous.

But on the other planets...

In terms of atmosphere Venus is the polar opposite. It is blanketed in an

JUPITER

The Solar System's biggest planet also has its thickest atmosphere – some 5,000km of hydrogen and helium. The distinctive bands that form its visible surface lie in the 50km ammonia and sulphur cloud layer of the upper atmosphere, each one kept in place by a powerful jet stream running faster than 350km/h; there are over 30 on Jupiter. The heat generated within it – which is more than it receives from the Sun – drives many storms, including the Solar System's largest, the Great Red Spot. This enormous red vortex has been raging since at least 1665, though it has started to shrink in recent years. There are many other smaller white storms too, producing lightning hundreds of times more powerful than Earth's.



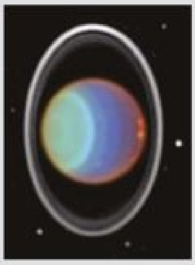
▲ Jupiter's belts and zones are home to innumerable storms and cloud systems

▲ This huge storm churned across the north of Saturn in 2015, circling the planet

SATURN

Saturn's banded structure is similar to Jupiter's, and it is kept in place some of the fastest winds in the Solar System, travelling at over 1,500km/h. Giant storms thousands of kilometres across break out around every 10 years; these can last over a month and spread around the planet. Saturn's poles both have curious atmospheric phenomena. In the clouds of the north pole is a permanent hexagon pattern like a standing wave in its clouds, thought to be caused by different rates of rotation; at the south pole lies a hurricane-like storm with a distinct eye – the only place other than Earth this has been seen.

THE ICE GIANTS



▲ Sunlight reflected from clouds and haze give Uranus a colourful appearance

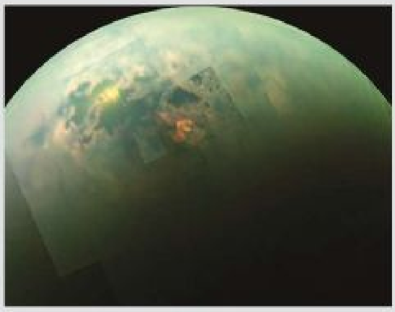
Uranus and Neptune have atmospheres of hydrogen, helium and methane gas above a layer of water, methane and ammonia ices. Uranus appears a uniform blue at visible wavelengths since its methane haze absorbs red light. Yet there's evidence of cloud bands and storms in infrared observations.

Voyager 2 witnessed bands of white clouds in Neptune's atmosphere during its 1989 flyby

Neptune's climate is surprisingly active, and home to the Solar System's fastest winds, which rip through the atmosphere at 2,150km/h. Bands of white clouds can be seen to drift above the planet's blue-coloured methane haze in visible light, while infrared reveals many more storms, both in bands and separately, driven by a mysterious heat source within the planet.

THE MOON WITH ITS OWN WEATHER

Saturn's moon Titan is the only moon with a thick atmosphere. It's also the only place other than Earth in the Solar System where standing lakes have been found. There are also clouds and rain here, all forming part of a climate cycle much like our water cycle. The one important difference is that here on Titan, it's a methane cycle. At this moon's surface temperature of –180°C methane is a liquid, falling as a drizzle from the clouds. This makes it possible that Titan could host rainbows, though the thick haze higher in the atmosphere might well cut out too much of the faint sunlight reaching the surface to make them visible.



▲ Sun glints off Titan's polar seas which, quite unlike Earth's, are formed of methane

incredibly dense atmosphere of carbon dioxide on top of which sit thick clouds of sulphuric acid – the result of several billion years of runaway greenhouse effect. This toxic mass is 60 times as dense as the air we breathe and weighs heavily on the surface, creating a pressure that's like being 1km underwater on Earth.

It also traps the Sun's heat to make Venus's surface hotter than Mercury's, with temperatures of at least 460°C. Winds are sluggish but because the air is so dense they have enough force to move small stones. And there's no respite from the oppressive conditions: from the poles to the equator, day and night the climate remains constantly inclement.

Roughly 100 million km farther from the Sun than Venus, Mars is a lot colder, with average temperatures well below freezing, yet its climate is more manageable for humans. Indeed, the Red Planet has seasons similar to Earth's, and Martian summers can see the climate warm up to 2°C. But since its carbon dioxide air is so tenuous all heat escapes when the Sun sets, and the temperature drops to –130°C. The chilly temperatures do produce carbon dioxide snow at Mars's poles, as recorded by NASA's Phoenix lander, which also observed high altitude clouds of ice scudding by in the rosy red sky. The rest of Mars's surface is a dry, dusty place and what sunlight does reach it whips up winds that create gigantic dust storms, sometimes enveloping the entire planet. These winds can also create smaller scale tornadoes which have been observed by orbiting spacecraft.

In the realm of the gas and ice giants we see even more extreme climates and weather, and that's not just on the planets. In the outer Solar System, moons have weather too. Ⓢ

Chris Bramley is *BBC Sky at Night Magazine*'s editor

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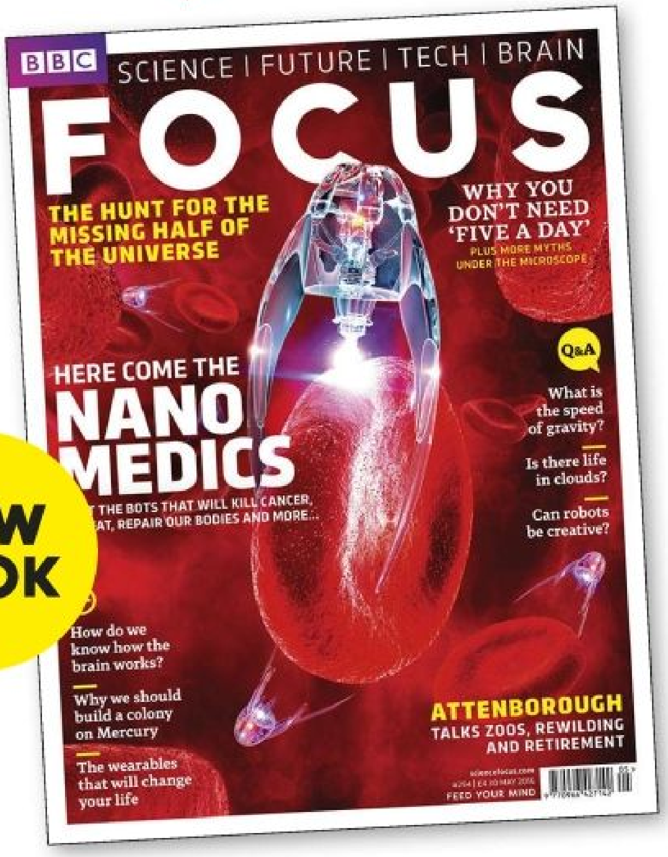
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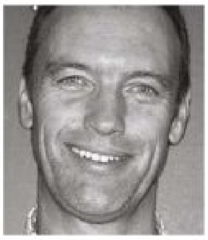
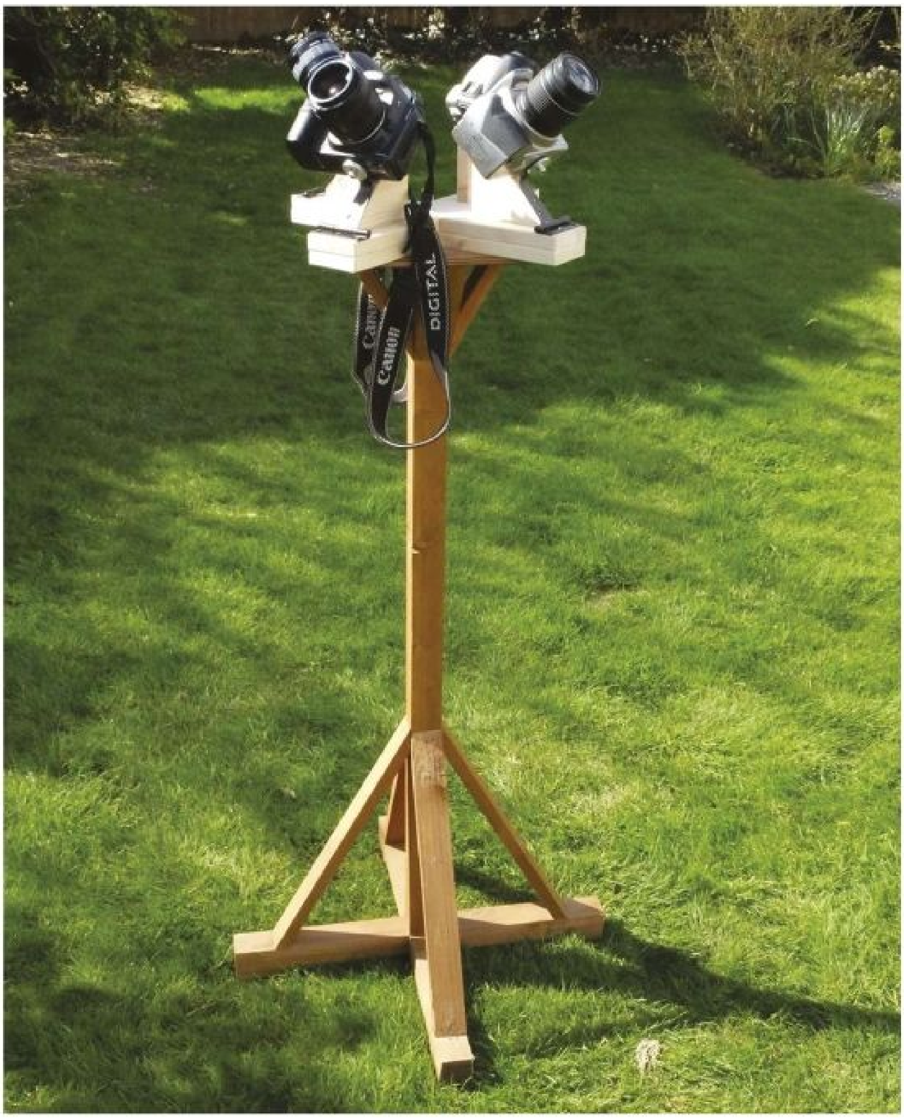


How to

Build a bird table mount

With **Mark Parrish**

Transform this garden staple into a stable mutli-camera platform



▲ **A bird table (top removed) forms a useful base because it is both sturdy and level**

TOOLS AND **MATERIALS**

TOOLS
Handsaw or equivalent, drill with bits to suit woodscrews, clamps or a vice, small hammer, screwdriver

MATERIALS
2.4m length 70x18mm softwood, four 70mm T-hinges with small screws

SUNDRIES
Four 60mm woodscrews, four 20mm ¼x20 bolts, M6 washers, 30mm panel pins, PVA wood glue, sandpaper, washing up sponge, gloss paint or varnish

With the prospect of no Moon after midnight, next month's Perseid meteor shower has the potential to be a spectacular sight. Just wrapping up warmly and sitting under the stars is a wonderful way to enjoy the show, but a photographic record of even just one elusive trail can be a beautiful memento, as well as being of scientific interest.

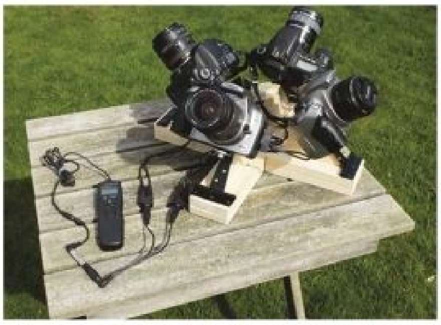
This month's project is a simple mount that enables you to aim up to four DSLR cameras towards the sky. How many you choose to use, and their orientation, will depend on what you have available. The principle is to cover as much sky and take as many images as you can in the hope of a bright trail appearing in one of the cameras' fields of view at just the right moment.

The DSLRs are mounted on hinged brackets pointing upwards towards the night sky. The hinges allow for individual cameras to be pivoted downwards during the imaging session in order to check the recorded images on their review screens, alter focus and exposure, and change batteries and memory cards. We called this a 'bird table' mount because it occurred to us that many gardens already have a bird table with a suitable tall post with a sturdy base, and if the birds aren't using it at night we may as well remove the top for a few hours for our meteor hunt. But if you don't have a bird table, don't worry. This mount can also be put on a table top or screwed onto a fence post, so it is quite versatile.

Four cameras?

There are lots of cheap, second-hand DSLR cameras on the market making this a financially viable project to contemplate. A secondhand Canon EOS 300S is a suitable candidate and with its modest-sized sensor and lens at 18mm it will cover approximately 45x60° of sky. Full frame cameras are more expensive but give coverage closer to 60x90° for the same lens so four could just manage a full 360° view. Don't be put off if you don't have four ▸

ALL PICTURES: MARK PARRISH



▲ **If you're clever with your connections, one intervalometer can control all four cameras**

▸ cameras; even two will double your chances of capturing that elusive image.

There are many considerations when determining the best direction in which to point your cameras, but the radiant (the point from which the meteors appear to emanate) will be approximately 45° above the horizon at midnight, so this is the altitude we chose. We suggest one camera pointing towards Perseus in the northeast, with any additional cameras increasing your chances of a capture elsewhere. If you wish to avoid sky gaps between cameras you could experiment by turning the supports, which is why we decided not to glue them.

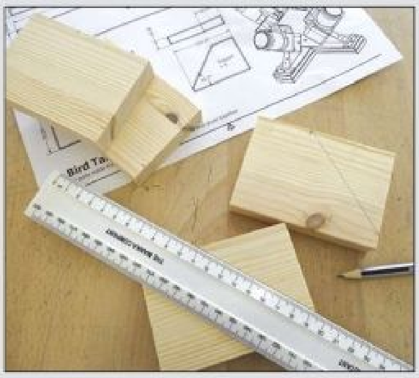
An intervalometer (remote timing/shutter control device) is also valuable, as this will enable you to set each camera to take regular exposures through the night. Connecting it all requires some crafty cabling. Start with a female to female audio jack that fits your intervalometer, and connect them. Attach a 3.5mm splitter cable to the other end of the audio jack and connect a splitter plug to each 'head' of the splitter cable. This gives you four sockets through which you connect four cameras to a single intervalometer.

All cameras have a standard threaded insert for attaching to a tripod. The thread size is 1/4x20 threads per inch and small bolts of this size can be bought online if you want to avoid an expensive version from a camera shop. We used a rubber washer below the camera and a few M6 metal washers in between each bolt and hinge to allow it to be tightened properly. If the camera vibrates a bit when the mount is knocked you can wedge some foam (cut up a clean, dry washing up sponge) between the camera body and wooden support, which dampens any movement. Ⓢ

Mark Parrish is a consummate craftsman who loves making astro accessories

YOUR BONUS CONTENT View a cutting template for this project

STEP-BY-STEP GUIDE

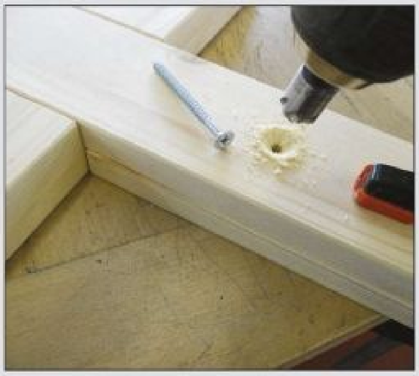


STEP 1

Use the dimensions on the printable plan included in this month's Bonus Content to mark out the timber to size. Your timber merchant may be able cut the softwood into suitable lengths for you. All you then need to do is cut the 45° angles on each support section.

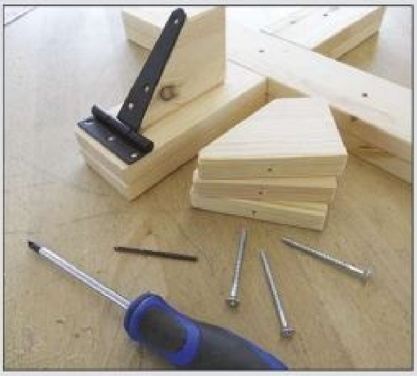
STEP 2

Use a saw to accurately cut the sections to shape. Power tools can help here, but a handsaw or tenon saw works fine. It helps to hold the wood in a vice, or clamp it to the bench. You may also wish to clamp some scrap wood to the bench to protect its surface.



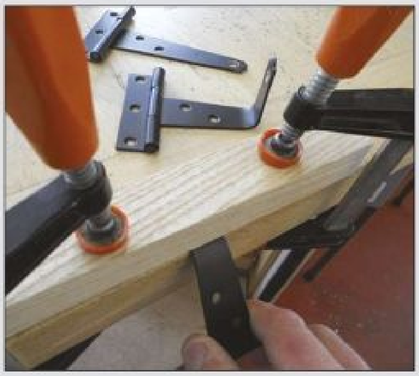
STEP 3

The main sections can now be glued together to form a two-layered cross. Use PVA wood glue for a strong fix; reinforcing the joints with panel pins will help hold them together while the glue sets. Drill and countersink a 5mm hole 80mm from the end of each arm.



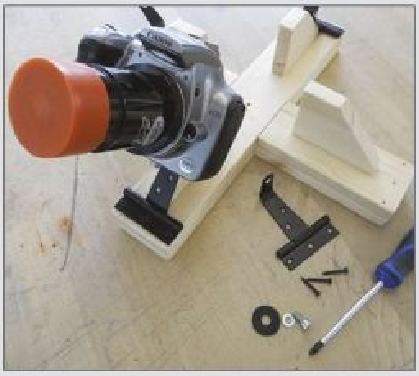
STEP 4

Each sloping hinge support needs a 3mm pilot hole for the screw. Ascertain each hole's position by testing with a hinge before drilling. The hinge should lie flat against the support and top of the cross. Fix each support from below with a screw (but no glue).



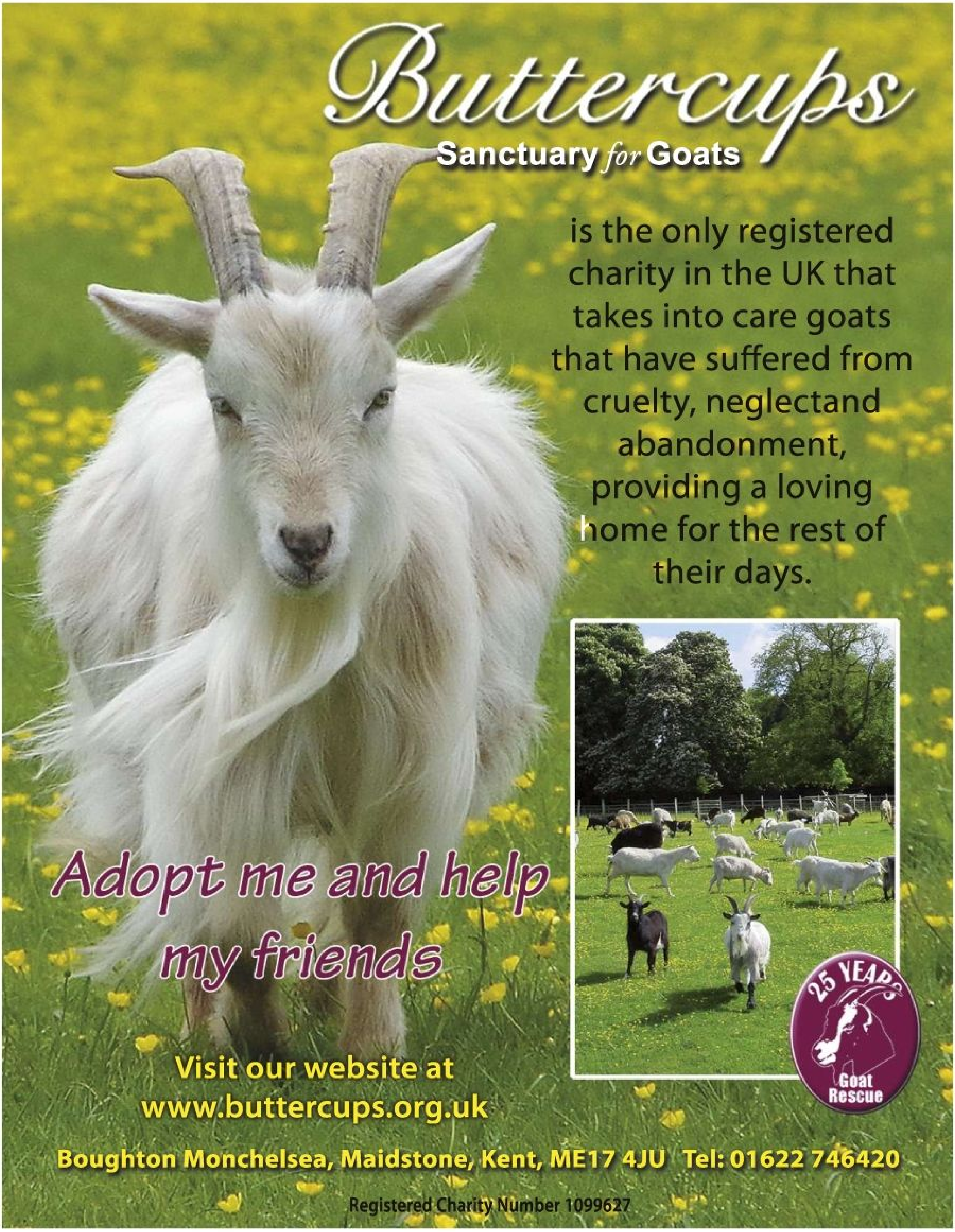
STEP 5

Drill out the outer hinge screwhole to 6.5mm diameter for the camera screw. Each hinge needs to be bent to 90°. Bend 35mm from the end by clamping between the bench and some scrap wood. Make sure you bend it the way shown in the image above.



STEP 6

After applying a nice varnish or paint finish, use small screws with pilot holes to attach the hinges. Test fit a camera to make sure it sits nicely. Adjust the bend of the hinge or introduce a bit of sponge padding to achieve a good fit.



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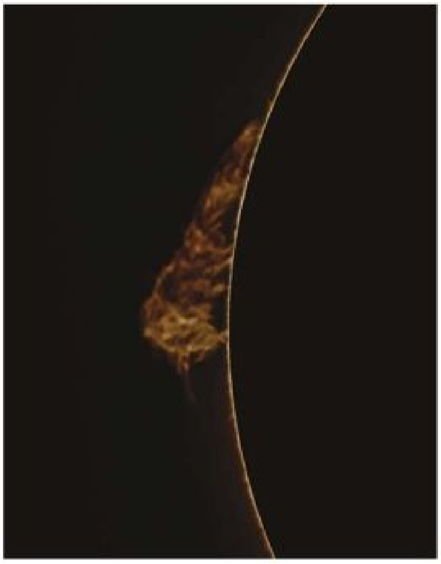
With **Mary Spicer**

Image PROCESSING

Using Focus Magic to sharpen solar images

This alternative can fix poor seeing, tracking problems and even motion blur



▲ The starting image, a large prominence captured with a DSLR and a Corondo PST

Image sharpening is a crucial part of processing, allowing you to both make your images look crisper and enhance fine detail. Traditional sharpening and 'unsharp mask' methods are to be found in programs like Photoshop and Paintshop Pro. These rely on local contrast enhancements around the edges of objects within a picture, in order to try and make the overall image look sharper. This can often make images look unnatural and it can introduce unwanted artefacts, something to be avoided at all costs.

The program we're going to use in this tutorial is Focus Magic (www.focusmagic.com), which is available to download as a stand-alone program or as a plug-in for Photoshop or Paintshop Pro. It works slightly differently, using a deconvolution routine to determine why an image is out of focus, then reverses and restores it. In an out of focus image, what should be a point source (a star) is an unfocused spot. This becomes a small circle with traditional sharpening methods. Focus Magic tightens those circles again and delivers a dramatic sharpening.

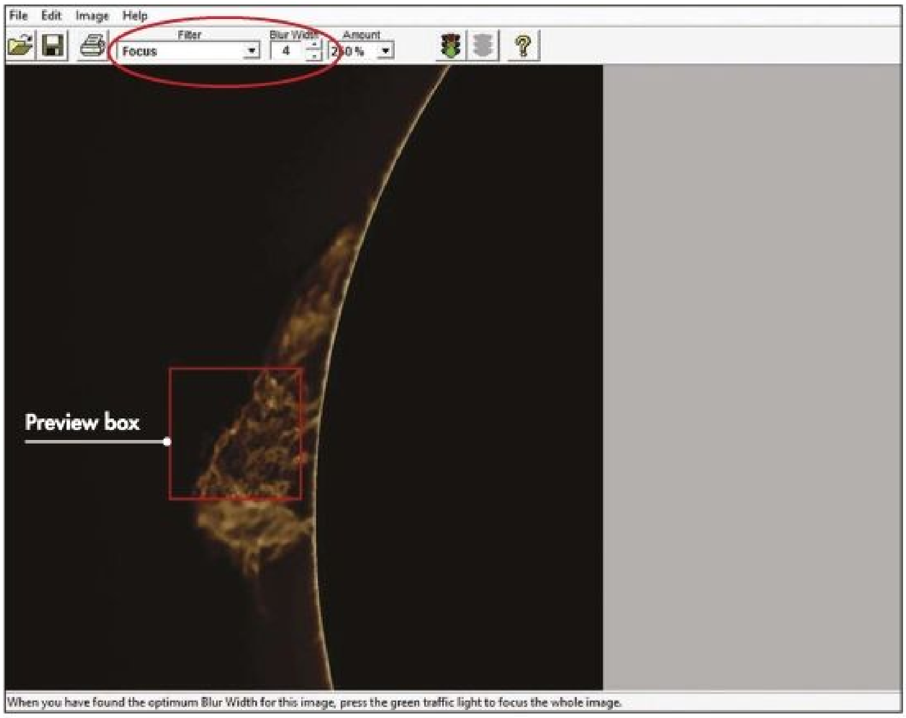
Focus Magic can be used to correct images that are slightly out of focus due to poor seeing conditions or if your focus wasn't as tight as it could have been at the time you took your shots. There is also the option to correct for motion blur, which can be an issue if your telescope mount didn't track properly or your images are beginning to show star trailing. Here we will show you how you can transform an image of a solar prominence using the 'focus' function – the same steps can be applied to solar surface features shot in white light or through a hydrogen-alpha solar telescope. The software is compatible with Jpeg and Tiff files.

The starting image is of a large prominence that was visible on 23 April 2015, taken with a Canon EOS 1100D DSLR attached to a Coronado PST on an EQ5 Pro mount and with a 2x Barlow lens fitted. It is a stack of 195 images. You will get the best results if you work on an image which has already had noise reduction applied to it.

Beating blur

Begin by opening Focus Magic. Click **File > Open** then select the image you want to sharpen. The first step in the sharpening process is to determine the blur width; this is a measure of how out of focus your starting photograph is. When you open the image, Focus Magic automatically determines this value for you and it is displayed in the Blur Width box at the top of the page.

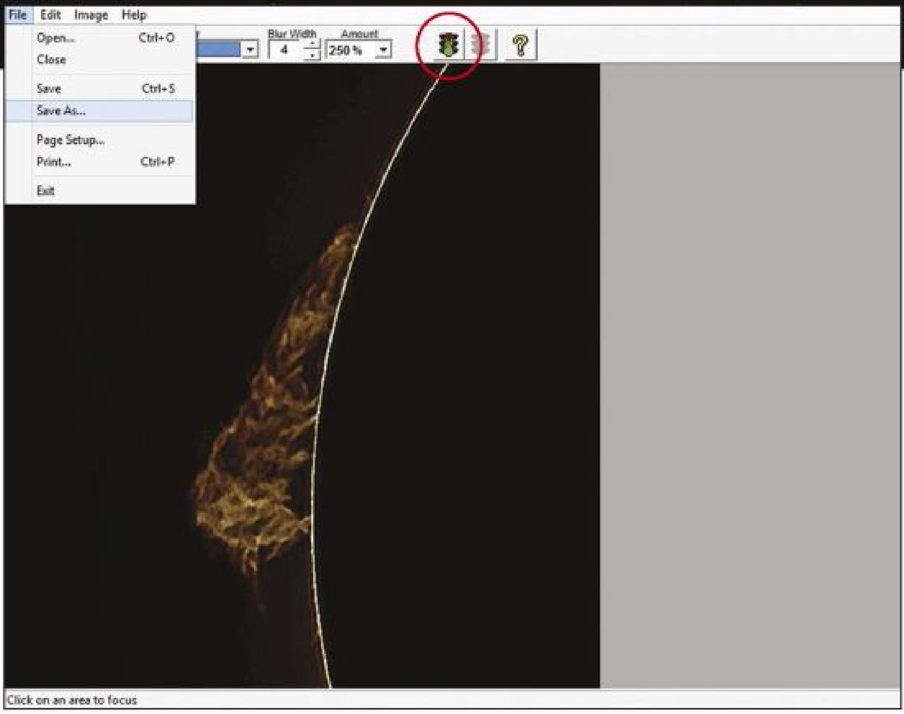
Click on the drop-down menu at the top of the page labelled **Filter** and



Filter: Focus
Blur Width: 4
Amount: 2[illegible]0 %

When you have found the optimum Blur Width for this image, press the green traffic light to focus the whole image.

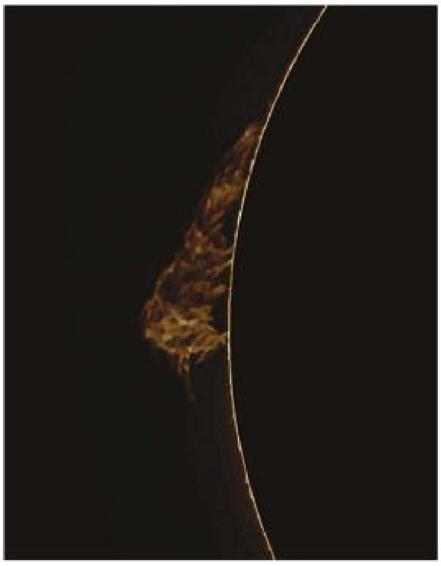
▲ Selecting the 'Focus' drop-down item brings up a preview box – use this to trial your tweaks



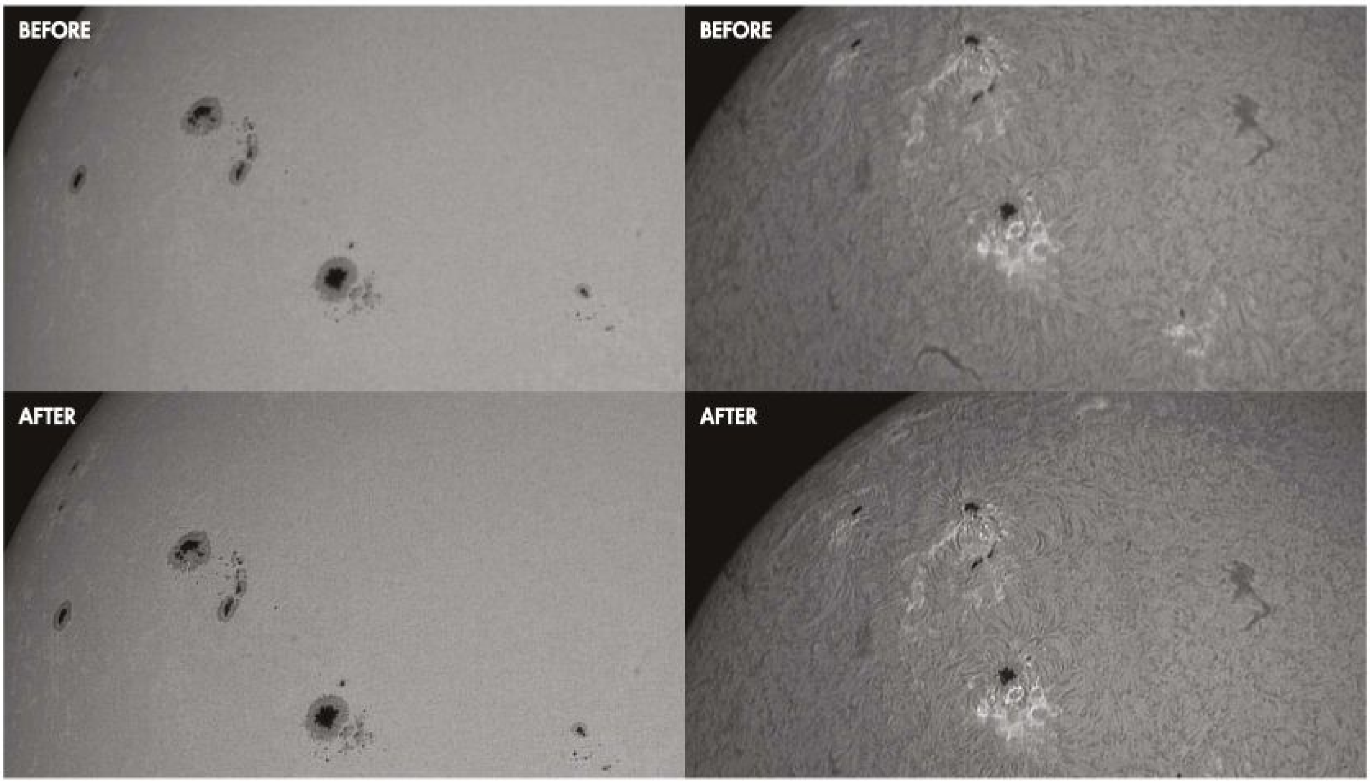
Blur Width 4
Amount 250 %

Click on an area to focus

▲ Clicking the traffic light icon confirms your changes and applies them across the whole image



▲ The final edited image of the solar prominence is altogether cleaner, sharper and shows more fine detail



▲ Solar active regions AR12109, AR12110, AR12108 and AR12107 in white light and hydrogen-alpha, before and after processing

select **Focus**. You will then see a small red box appear on your image; this is the preview box. Focus Magic will by default focus using the blur width value that it determined automatically when you opened the image.

To move the box around and preview the effect of that level of focus adjustment, simply click on your image. Experiment by changing the blur width value using the up and down arrows alongside the box until you are happy with the result. If you push this value too much higher than the starting point, you can begin to introduce artefacts into the image. Once you've decided on the optimum blur width, move onto the percentage box. Once again, use the preview window to test different percentage levels and select the value that gives you the best result.

When you have found the optimum values, click on the green traffic light box at the top of the page and it will apply the settings to the rest of the image. To save your adjusted image, click **File** > **Save As** and input the file name. Your image is finished.

The final image on this page shows the effect of using Focus Magic on a group of active regions (AR12109, AR12110, AR12108 and AR12107, imaged in July 2014) in white light and hydrogen-alpha. In both cases you can see an improvement in the crispness of the images and an enhancement of the fine detail. Ⓢ

Mary Spicer is a passionate astro imager based in Oxfordshire

ALL PICTURES: MARY SPICER

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With **Steve Richards**

Scope DOCTOR

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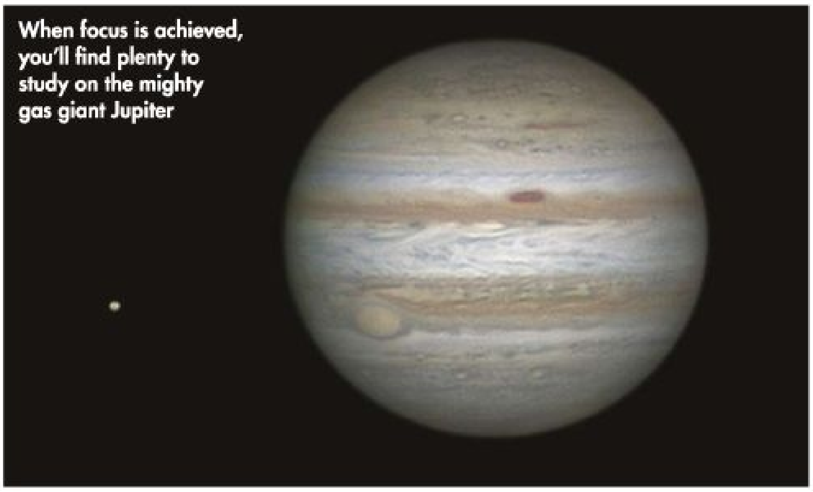
With my Meade LS8 and electronic focuser, I can focus on Jupiter fine with 15mm and 20mm eyepieces but cannot achieve focus with 9mm and 12mm ones. Any suggestions?

RICK SANDILANDS



When focus is achieved, you'll find plenty to study on the mighty gas giant Jupiter

The Meade LS8 telescope is an 8-inch Schmidt-Cassegrain with a focal length of 2,000mm and a self-aligning altazimuth mount. You say you also have a Meade Zero Image Shift-Electronic Microfocuser, which attaches to the visual back of the telescope, before the star diagonal, to give a secondary focusing system under electronic control. The microfocuser has about 25mm of movement so it is still necessary to adjust the coarse focusing using the telescope's manual focus knob, which moves the primary mirror inwards and outwards.

You appear to be having trouble with your higher focal length, lower magnification eyepieces. This can cause problems when trying to image a target such as Jupiter, as the moons will not form clear points of light. Although the insertion of the electronic focuser does reduce the available focus backspace there is still ample coarse focus travel using the telescope's focus knob to compensate for this. It is very unlikely that this is the cause of the problem.

To ensure that you are operating within the correct focus region, select your 15mm eyepiece, set the electronic microfocuser to its half-way position and then focus on a bright star or Jupiter using the telescope's focus knob. Now replace the 15mm with your 12mm eyepiece and use the microfocuser to achieve focus.

If you are still unable to achieve focus then it is most likely that you are at the limit of magnification for your seeing.

DIETER RETZL/CCDGUIDE.COM, STEVE RICHARDS

STEVE'S TOP TIP

How can I make using my refractor more comfortable?

Light passes through a refracting telescope, exiting at the rear of the optical tube. When viewing objects high in the sky, the rear of the telescope will be pointing downwards leading to an uncomfortable viewing position.

A diagonal is a small adaptor which, for most astronomical purposes, contains a mirror placed at a 45° angle which turns the light through 90°. This means that the sky can be viewed by looking downwards at a much more comfortable angle. A mirror diagonal produces an image correctly orientated in the vertical plane but reversed in the horizontal plane.

The ideal cleaning kit: an air blower, lens tissues, isopropyl alcohol and a microfibre cloth

I've noticed spots on my refractor's lens and eyepieces from dried dew. What is the best way to clean them?

VICKI STERLING

Water marks on lens and eyepiece surfaces are quite common unless you use a dew heater on both, though as they are unlikely to have a detrimental effect on observing you can, for the most part, simply ignore them. However, astronomers are a fastidious bunch and the time will come when you just won't be able to leave well alone, but take great care during the cleaning process to avoid scratching the optical surfaces. Never be tempted to disassemble the lens elements as this could destroy the manufacturer's careful alignment.

When the time to clean does arrive you will need an air blower with the brush removed, lens cleaning tissues, isopropyl alcohol and a microfibre cloth. Remove surface dust with several blasts of the air blower, wet a cleaning tissue with the alcohol and gently wipe the lens from the centre outwards and while the alcohol is still present, gently polish the lens surface.

Steve Richards is a keen astro imager and an astronomy equipment expert

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90

Setting up time is pared back to a bare minimum with Meade's 5-inch tabletop Dobsonian

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FIRST **light**

See an interactive 360° model of this telescope at
www.skyatnightmagazine.com/lightbridge130

Meade LightBridge Mini 130 Dobsonian

Get observing in minutes with this tabletop scope – all you need is a flat surface

WORDS: PAUL MONEY

VITAL STATS

- **Price** £225
- **Aperture** 130mm (5.1 inches)
- **Optics** Parabolic mirror
- **Focal length** 650mm (f/5)
- **Mount** Wooden altaz
- **Extras** Red-dot finder, 9mm and 26mm eyepieces (1.25-inch fit), Autostar software
- **Weight** 6.1kg
- **Supplier** Hama
- **https://**uk.hama.com
- **Tel** 0333 123 4262

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The miniature Dobsonian is a recent trend; now Meade has entered this fledging market with its LightBridge Mini 130, a lightweight, tabletop instrument with a 5-inch aperture.

This Dobsonian is shipped already assembled and is well packaged for protection during transit, with a smaller box containing a red-dot finder, two eyepieces (26mm and 9mm), instructions and Meade's Autostar planetarium software. The eyepieces are 1.25-inch fit and give magnifications of 25x and 72x; in other words, low- and medium-powered views. The finder is a zero-magnification variety and the brightness of its red dot is adjustable, though we found that the lowest setting was best so as not to overpower the view.

The single-arm mount delivers free movement along both the azimuth and altitude axes and is easy to operate. The telescope tube attaches via a Vixen-style clamp and can be removed if needed. This allows you to opt for an alternative mount (such as an EQ1 or EQ3) if you wish to upgrade to an equatorial system at a later date. But, because the telescope is fixed via a Vixen-style bar in this way, we did find that in some positions it was not easy to reach around and look through the red-dot finder to align on a target without stretching over the focuser assembly and eyepiece. Perhaps if the finder was located a little closer to the focuser this might improve the system.

> **SKY SAYS...**
> Regulus was pin sharp across 75 per cent of the view with slight distortion towards the edge

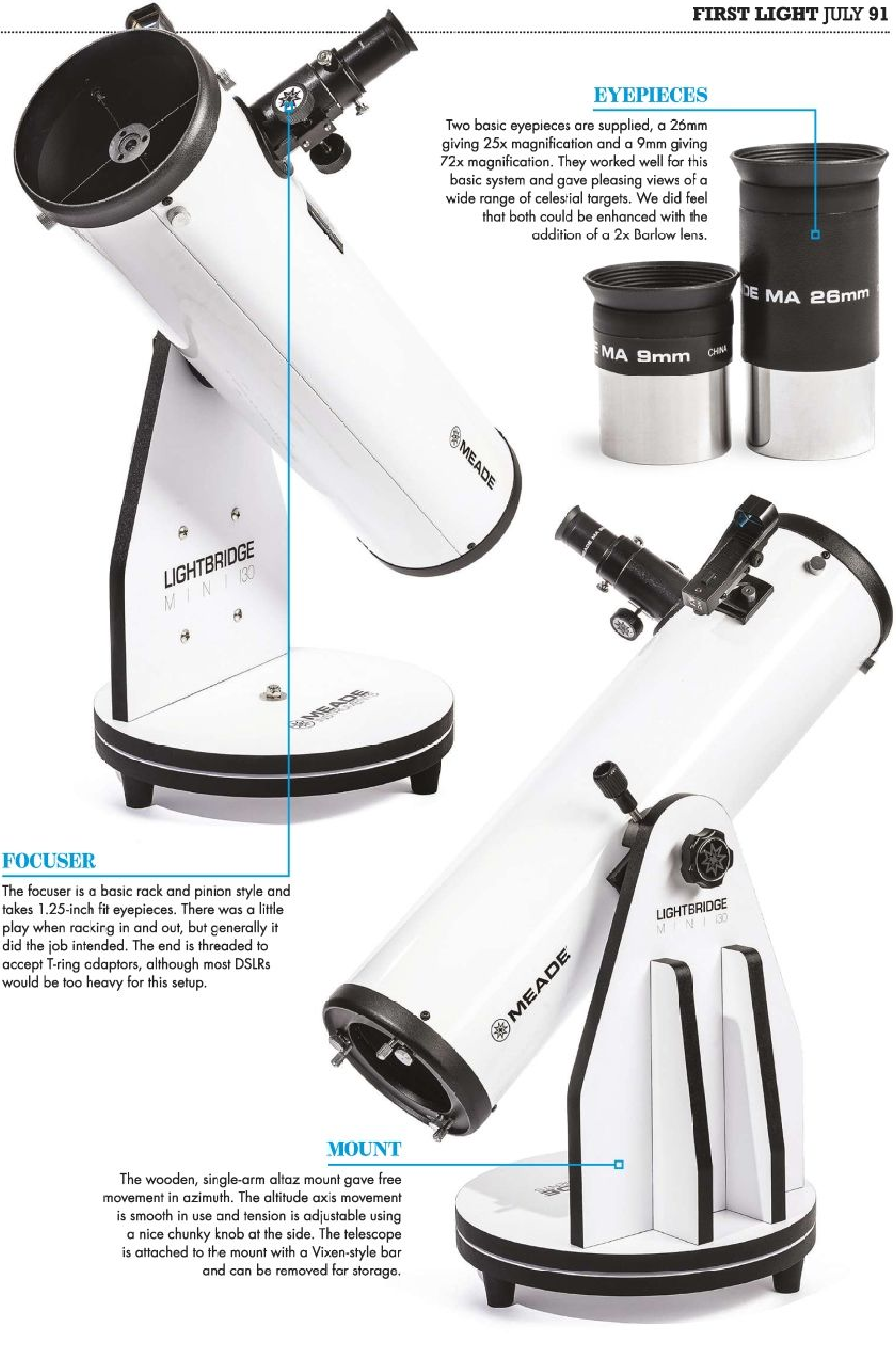
We placed the LightBridge Mini 130 on the observing trolley we often use for a laptop and were quickly in action with the 26mm eyepiece. We checked the field of view by aiming at the bright star Regulus in Leo, and were pleased to see it was pin sharp across 75 per cent of the view with slight distortion towards the edge. The 25x magnification of the 26mm eyepiece delivers a wide field of view of just over 2.5°, so even quite large star clusters such as M44, the Beehive Cluster in Cancer, will fit in the view. The galaxy pair of M81 and M82 in Ursa Major could be seen together even when we changed to the 9mm eyepiece (72x magnification) and were a lovely sight with a hint of subtle structure running along the almost edge-on disc of M82.

Messier hopping

M51, the Whirlpool Galaxy in Canes Venatici, was small but relatively bright in the 26mm eyepiece, its companion galaxy M51a clearly visible, while the 9mm eyepiece enhanced the view – revealing a hazy disc surrounding the main core of M51. Turning to what few nebulae there were to see in the spring sky, we enjoyed a good view of M57, the Ring Nebula in ►

PICK UP AND GO ANYWHERE

Tabletop telescopes are naturally portable and easy to set up anywhere there is a flat surface to stand them on that leaves the eyepiece accessible. Because of this you can be viewing through the LightBridge Mini 130 in minutes – free of the hassle of unfurling a tripod, polar aligning or setting up a Go-To. You could easily take it to a dark site away from home, or simply rush it out into your garden to catch elusive gaps in the cloud that might be too brief for more advanced setups. Appealing to a wide range of people, from the young to not so young, it is also a great way to introduce the Universe to anyone even vaguely interested in astronomy and space. Small instruments are often considered inferior to more complicated ones, but in our experience the value of a telescope entirely depends on the user. Certainly, the LightBridge Mini 130 provides views that can inspire a greater appreciation of the night sky.



EYEPIECES

Two basic eyepieces are supplied, a 26mm giving 25x magnification and a 9mm giving 72x magnification. They worked well for this basic system and gave pleasing views of a wide range of celestial targets. We did feel that both could be enhanced with the addition of a 2x Barlow lens.

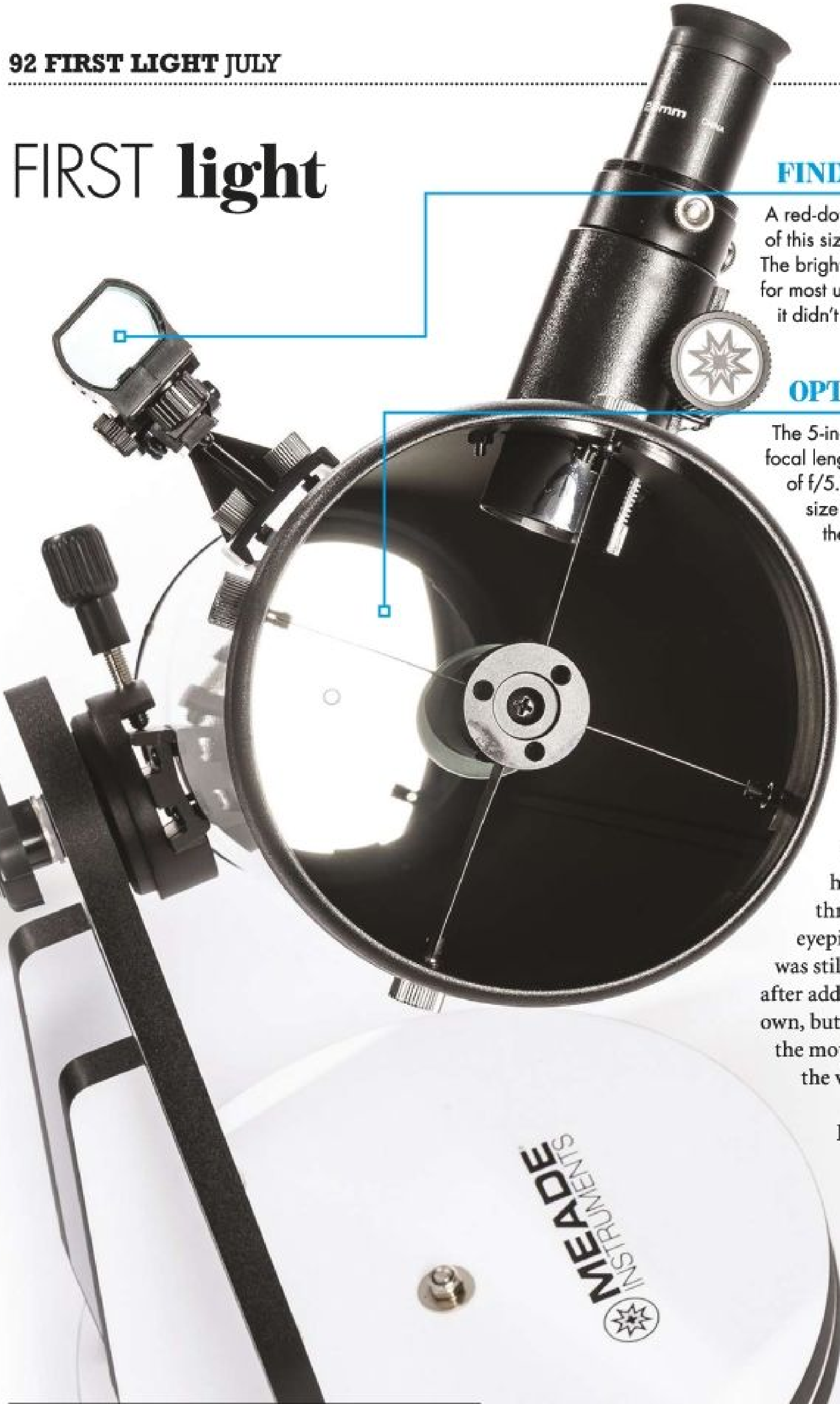
FOCUSER

The focuser is a basic rack and pinion style and takes 1.25-inch fit eyepieces. There was a little play when racking in and out, but generally it did the job intended. The end is threaded to accept T-ring adaptors, although most DSLRs would be too heavy for this setup.

MOUNT

The wooden, single-arm altaz mount gave free movement in azimuth. The altitude axis movement is smooth in use and tension is adjustable using a nice chunky knob at the side. The telescope is attached to the mount with a Vixen-style bar and can be removed for storage.

FIRST **light**



FINDER

A red-dot finder is a reasonable choice for a telescope of this size as it is simple to use and quite lightweight. The brightness of the red dot can be adjusted, though for most uses we found the dimmest setting the best so it didn't overpower the view.

OPTICS

The 5-inch parabolic mirror has a relatively short (fast) focal length of 650mm, giving the system a focal ratio of f/5. The optics performed reasonably well for their size and provided a range of pleasing views from the Moon and planets to brighter deep-sky targets.

► Lyra, with a nice dark hollow at its centre, and nearby M27, the Dumbbell Nebula, showed hints of structure through the 9mm eyepiece. The view was still reasonably detailed even after adding 2x Barlow lens of our own, but as this also had the effect of enhancing the motion of the sky we had to keep centring the view regularly.

Multiple stars and the planets require higher magnification as a rule, so we tried this using the 9mm eyepiece – we were able to pick out and split Castor in Gemini and Algieba in Leo. Jupiter also required the 9mm eyepiece and through it we could easily see the two main belts and the four Galilean moons. In moments of steady seeing we could even make out hints of more structure. Our near neighbour, the Moon, appeared bright but revealed plenty of craters that you can explore and impress your neighbours with.

Overall this is a simple to use tabletop Dobsonian that has the potential to fire the imagination of young and old, and give good views of a wide range of targets. Ⓢ

SKY SAYS...

Now add these:

1. Red LED torch
2. 1.25-inch 2x Barlow lens
3. Lunar/ planetary filter set

◄ The Moon, taken through the 26mm eyepiece afocally using an iPhone 6 Plus

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VERDICT	
ASSEMBLY	★★★★★
BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★☆
FEATURES	★★★☆☆
OPTICS	★★★★☆
OVERALL	★★★★☆

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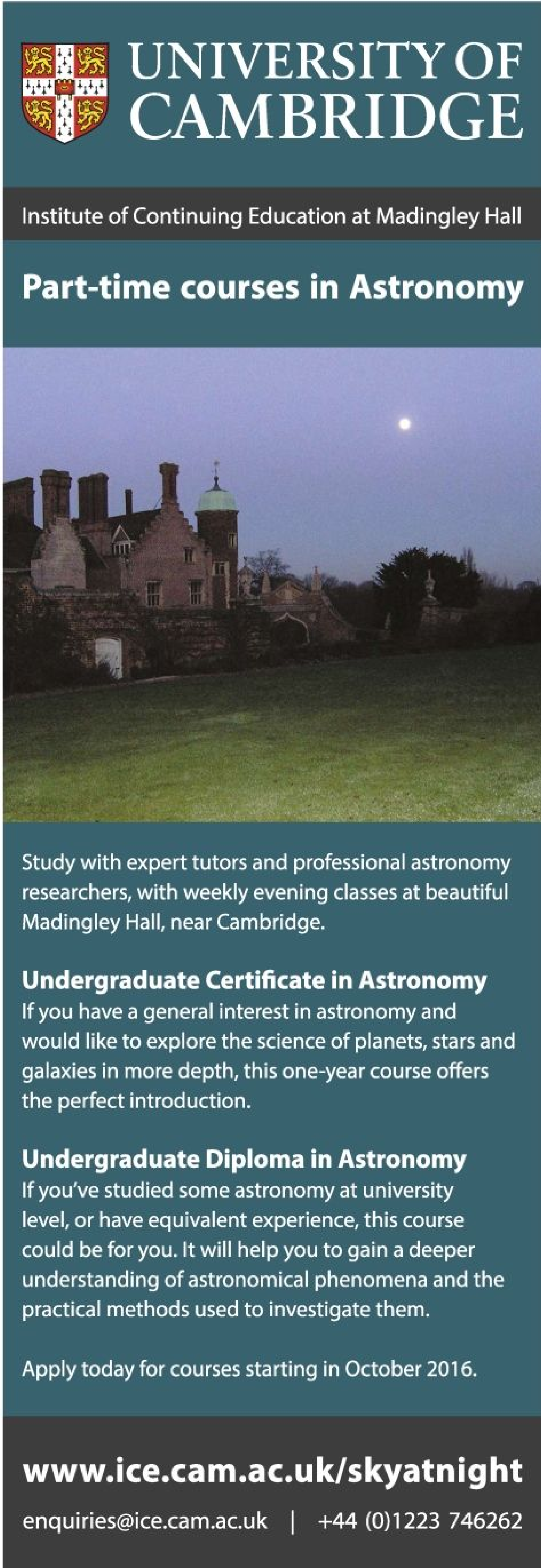

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FIRST **light**

See an interactive 360° model of this filter at
www.skyatnightmagazine.com/quarkcah

Daystar Quark calcium-H eyepiece filter

You've seen the Sun in white light and hydrogen-alpha red; now see it in purple

WORDS: MARK TOWNLEY

VITAL STATS

- **Price** £899
- **Tuning range** 5 Angström FWHM (+/– 0.5 Angström in 0.1 Angström increments)
- **Power requirements** 5V 1.5 amp
- **Extras** 1.25-inch and 2-inch nosepieces, 1.25-inch extension tube, 240V power supply, storage case
- **Weight** 200g
- **Supplier** Astrograph
- **www.astrograph.net**
- **Tel** 0843 330 4988

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Back in April 2014, Daystar announced a new product, the Quark hydrogen-alpha eyepiece filter. Designed to fit into the star diagonal of a refractor, it allowed observers to view the Sun at this popular wavelength through their regular eyepiece. And, unlike existing hydrogen-alpha filters and dedicated solar telescopes, it was comparatively cheap.

The filter quickly gained a following, and it wasn't long until amateurs were enquiring whether there would be a calcium version – and this is it. The calcium-H Quark is supplied with a plastic bolt case, 1.25-inch and 2-inch eyepiece snouts, a 1.25-inch extension nosepiece and a 90-240V plug adaptor. As the calcium-H wavelength is 396.85nm, in the violet region of the spectrum, the views of the solar chromosphere it delivers are quite different to what you might expect through a hydrogen-alpha filter.

The calcium-H Quark is designed to be used with refractors with a focal ratio of f/7 or greater, and as with any form of solar observing precautions must be taken. If you have an unguided mount and your scope's aperture is less than 80mm (3.14 inches), Daystar states that no additional filtration is needed. However, if you have a guided mount or your scope has an aperture greater than 80mm, you will also need an energy rejection filter (ERF).

SKY SAYS...
The simplicity and ease of use of the calcium-H Quark make it suitable both for seasoned solar observers and beginners

You can't use a conventional ERF, Herschel wedge or white light filter with the calcium-H Quark as this will block the target wavelength. Instead, Daystar recommends using an ultraviolet/infrared-cut filter on the nosepiece of star diagonal – and only for apertures up to 150mm (6 inches). You have to take care here, as calcium wavelengths fall outside the passband of some ultraviolet/infrared filters, so it is always good to check a prospective filter passes 397nm before purchasing. For the purpose of this review we opted for a 2-inch Baader blue CCD dielectric filter to use as an internal ERF as this offers more blocking than the ultraviolet/infrared-cut filter.

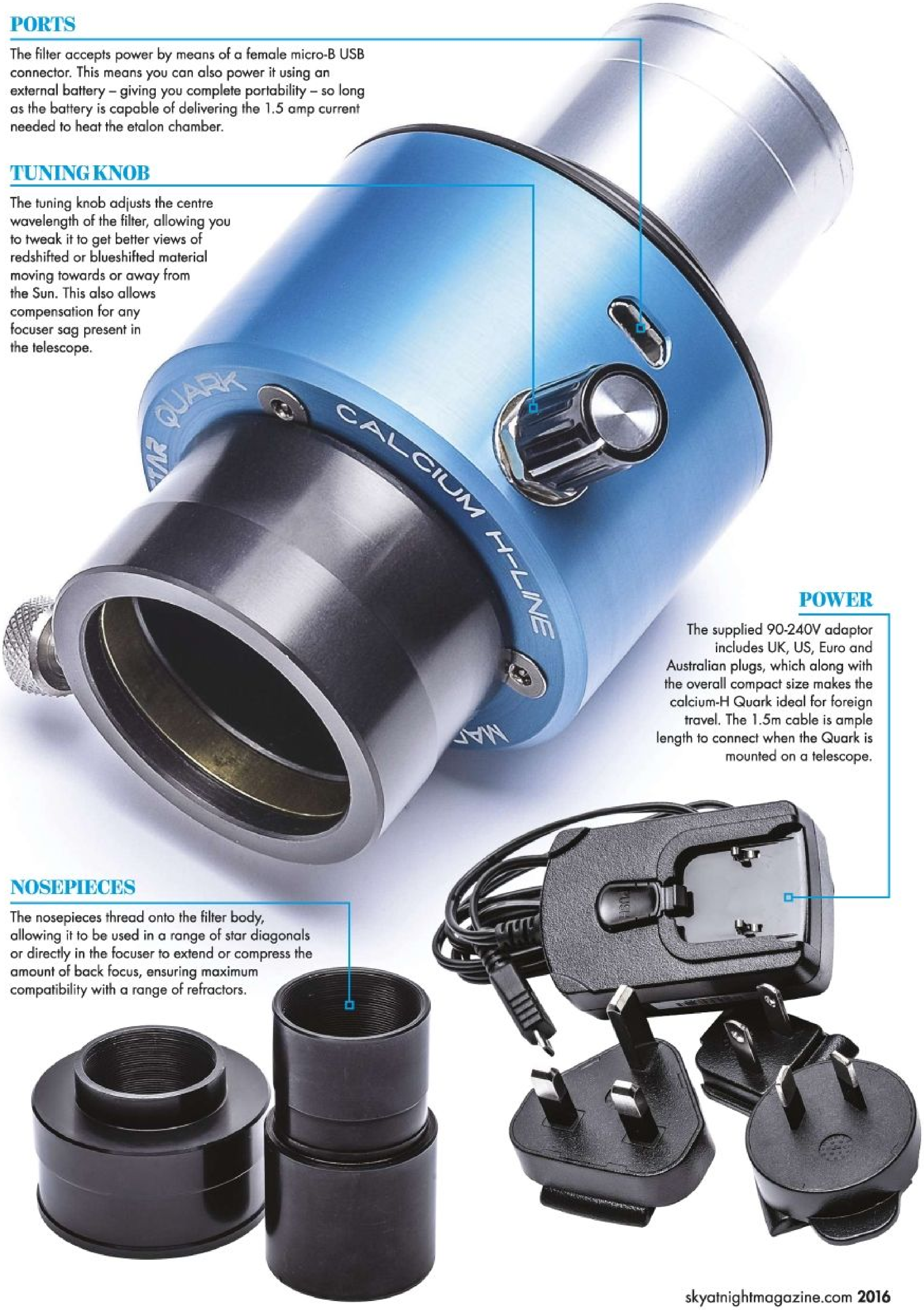
Engaging the etalon

We used the filter with a 100mm f10 Tal100R refractor, placing it in the diagonal with the ERF. Upon powering it up the indicator LED was yellow, but some 10 minutes later turned green, showing the etalon filter chamber was at the required temperature, on band and ready to use.

Using a 15mm Plössl eyepiece gave us a rich and well contrasted view of the full solar disc, and it was easy to see the brighter areas of plage and faculae set against the violet background. Darker sunspots with their umbra and penumbra could also be seen ▸

THE BOONS OF BRIGHTNESS

The calcium-H Quark provides a bright view that is easy to see as the calcium-H line is closer to the visual spectrum. The 5 Angström passband of the filter lets through plenty of light safely but also still keeps contrast high, delivering a detailed, violet-coloured view. We asked a range of observers to try the filter, from young children through to adults in their 70s, and all could see the image through the eyepiece, so we can say it would be great for use at outreach events. When it comes to imaging, the brightness means that exposures can be kept short, allowing sharp frames that capture periods of steady seeing. The fact that the calcium-H line is nearer the visual spectrum also enables cameras to have higher quantum efficiency, while affording lenses higher transmission and superior performance from typical anti-reflection coatings.



PORTS

The filter accepts power by means of a female micro-B USB connector. This means you can also power it using an external battery – giving you complete portability – so long as the battery is capable of delivering the 1.5 amp current needed to heat the etalon chamber.

TUNING KNOB

The tuning knob adjusts the centre wavelength of the filter, allowing you to tweak it to get better views of redshifted or blueshifted material moving towards or away from the Sun. This also allows compensation for any focuser sag present in the telescope.

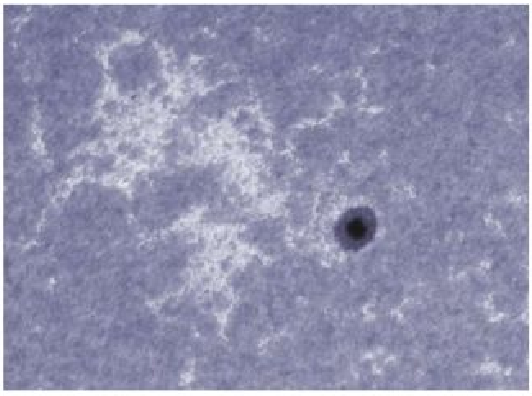
POWER

The supplied 90-240V adaptor includes UK, US, Euro and Australian plugs, which along with the overall compact size makes the calcium-H Quark ideal for foreign travel. The 1.5m cable is ample length to connect when the Quark is mounted on a telescope.

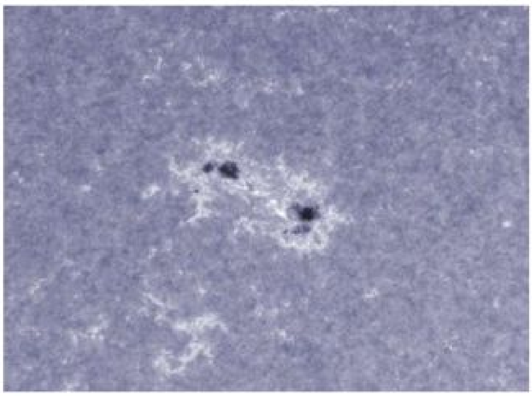
NOSEPIECES

The nosepieces thread onto the filter body, allowing it to be used in a range of star diagonals or directly in the focuser to extend or compress the amount of back focus, ensuring maximum compatibility with a range of refractors.

FIRST **light**



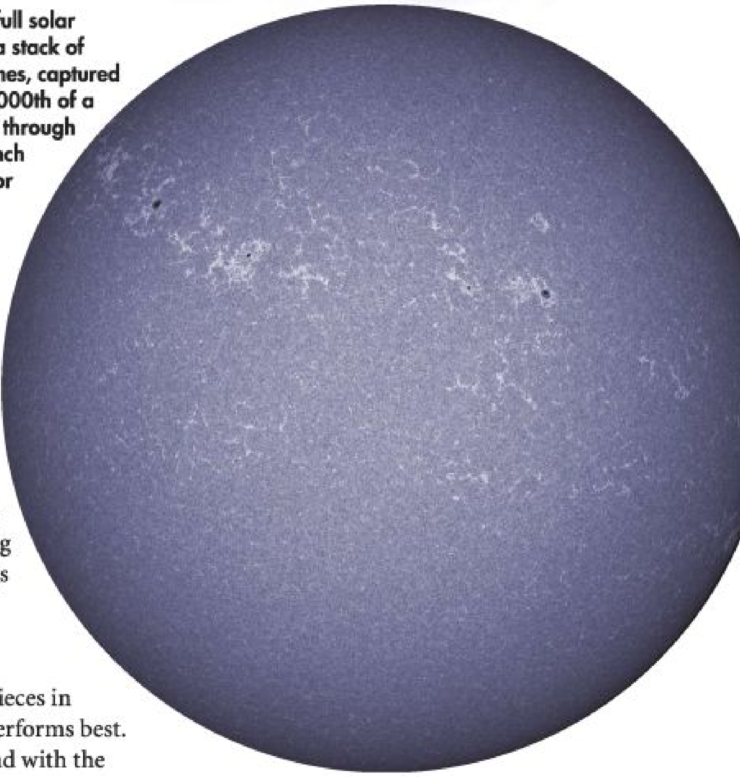
▲ Large single sunspot AR12519, stack of 32 frames of 1/200th of a second imaged with a 4-inch telescope



▲ The smaller multiple sunspots of AR12521, a stack of 32 frames imaged with the same setup as above

CASE

The supplied plastic bolt case provides a robust and sturdy means of storage. Daystar suggests that keeping the calcium-H Quark in a dry, climate-controlled environment when not in use will extend the lifetime of the filter by two or three times.



► This full solar disc is a stack of 32 frames, captured at 1/2,000th of a second through a 1.5-inch refractor

► within the active regions, and stood out nicely. It was interesting to note that the brightness and quality of view was eyepiece dependent, with this being down to the anti-reflective coatings and designs of the individual eyepieces, rather than the Quark eyepiece filter itself. It is worth experimenting with different eyepieces in your collection to see which one performs best. The highest contrast views were had with the tuning knob in its central position, although either side of this the contrast was still good.

On replacing the eyepiece with a monochrome PGR Blackfly camera, it immediately became apparent there was a lot of light reaching the CMOS chip, allowing for a fast frame rate and short exposures. The field of view was flat and even with no sweet spot, banding or the Newton's rings that sometimes become visible when imaging in hydrogen-alpha.

The simplicity and ease of use of the calcium-H Quark make it suitable both for seasoned solar observers wanting to see our star in a new light and beginners who want to get into solar astronomy. Given how easy it is to both image and observe with this eyepiece filter, Daystar may well have added a game changer to its product line. Ⓢ

SKY SAYS…
Now add these:

1. Astronomik ultraviolet/infrared-cut filter
2. EMC solar shield
3. APM 2.7x Photo Visual Barlow lens

VERDICT

BUILD & DESIGN	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★☆
IMAGING QUALITY	★★★★☆
VISUAL QUALITY	★★★★★
OVERALL	★★★★★

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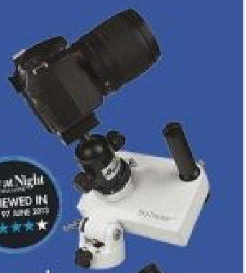
iOptron®

SkyTracker v2 DSLR mount



Take pictures of the night sky without star-trails! The adjustable AZ-base fits camera tripods, so no need to buy a separate base. 3.5kg payload. Illuminated polar scope included, which can even be used whilst imaging! Optional smartphone Apps for fast setup.

Sky Guider DSLR mount

The "big brother" to the Sky Tracker, with a 5kg payload, for larger DSLR camera lenses or small refractor telescopes. Smartphone-App-compatible polar scope, sturdy tripod, counterweight, plus ST4 guide port. Travel cases included for mount and tripod! Easy astro-imaging on-the-go!

Cube PRO GOTO AZ mount

An airline-portable GOTO mount which is both accurate and reliable, with metal gearing and a 4.5kg payload. Wether it's visual "grab 'n go" night-time astronomy, or even daytime solar viewing, the Cube PRO delivers. Easy setup with built-in GPS and 130K object database. 4.5kg payload.

AZ PRO mount

New featuring "level and go" intuitive GOTO setup. Light, compact and portable, with 15kg capacity. The #1 choice for easy GOTO visual observing in the field. Tough carry-case, 130K object database with GPS. Acclaimed GOTO accuracy and tracking ability.

Smart EQ PRO GOTO mount

Compact ULTRA portable EQ mount with full GOTO features for light weight imaging or visual observing. DC or battery power. 59K GOTO Database. Supports auto-guiding. Head only weight 2.8kg, 4.5kg Max payload. Includes the iOptron polar scope which is compatible with the polar alignment smartphone app. "Airline-portable GOTO-imaging".

CEM25 GOTO mount

New ultra-smooth, quiet hybrid stepper drive. "Centre-Balanced" equatorial mount for 12kg payload and only 4.7kg head. Compact and portable. The illuminated polar scope is always unobstructed for easy alignment checks. 59K GOTO objects, auto-guide port, and GPS. Amazing value.

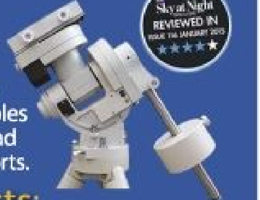
iEQ30-PRO GOTO mount

Now with super quiet hybrid drive stepper motors. Light, portable, with class-leading features: GPS, polar alignment assistance, polar scope, 130K object database, plus ST4 guide-port. 13.5 kg Max payload yet only 6.4kg head-weight. Precision worm gears for smooth tracking.

iEQ45-PRO GOTO mount

Now with hybrid drive stepper motors, this GOTO mount delivers for imaging or visual observing. 20kg Max payload, only 11.4kg head-weight. A class leader for portability and setup time. Field pier or permanent observatory pier available.

CEM60 & CEM60-EC GOTO



For observatory, or field use with larger telescopes. Very high tracking accuracy, advanced GOTO with 300K + objects, high resolution encoders, GPS polar-align assistance. Optional real-time PEC enables ultra-sharp imaging. 27kg Max payload, 12.3kg head weight! Through-cabling for power, with 4x USB ports.

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FIRST **light**

See an interactive 360° model of this mount at
www.skyatnightmagazine.com/azmountpro

SKY SAYS…
We centred on Jupiter and walked away; three hours later, it was still held in a central position

iOptron AZ Mount Pro

A mount that aims to take the hassle out of set up and let you get on with observing

WORDS: TIM JARDINE

VITAL STATS

- **Price** £1,299
- **Load capacity** 15kg primary payload, 4.5kg secondary payload
- **Hand controller** Go2Nova 8407 V2 handset
- **Database** 212,000-plus library, up to 60 user-defined objects or comets
- **Flash upgradeable** Yes
- **Autoguider port** N/A
- **Weight** 16Kg
- **Supplier** Altair Astro
- **www.altairastro.com**
- **Tel** 01263 731505

The first night under the stars with a mount often can be a confusing experience, with alignment routines requiring a working knowledge of star names and positions. The AZ Mount Pro from iOptron provides a simple setup routine that makes alignment easy, even for complete beginners. The company calls this technology 'Level & Go', and it promises to remove the rigmarole of setting up for a night of astronomy, allowing you to get on with the business of actually observing things.

We were pleased to see that the mount is supplied with an aluminium case and a sturdy tripod with easy to use adjusters that lock and hold tightly. The mount head is supported on three brass adjusters. These are the key to the all-important levelling process, and once the mount was placed in position, we found them easy to adjust. The bubble level on the AZ Mount Pro has been accurately placed, and when centred, did indeed show that the mount was set level. We found it a little tricky to use the bubble level under red light, which may be worth considering for those sharing a dark site with others.

The method of levelling is similar to telescope mirror collimation, adjusting three screws in turn. The 'Go' part, which aligns the mount with the sky, is a simple case of pressing a button – find out more in the outstanding feature box below.

The saddle for attaching a telescope will accept both Vixen- and Losmandy-style dovetail bars. Disappointingly, we discovered that when using a Losmandy-style bar from two common telescope manufacturers, the saddle did not clamp tightly enough to safely hold the telescope.

For our first tests we mounted a 3-inch refractor and, with the AZ Mount Pro turned on and alignment routine completed, found it worked wonderfully. It easily placed our desired targets▸

LEVEL & GO TECHNOLOGY

The AZ Mount Pro combines GPS capability with positional sensors and computer routines to simplify the initial alignment setup with as little user intervention as possible. After levelling the mount we just turned it on and waited until it had found its place in the cosmos. And we didn't have to wait long: in under two minutes the mount had set its position, determined which object in the sky was brightest, and slewed the telescope towards it. The handset then prompts the user to centre the object using the azimuth controls, (rotate left and right), and finally to fine tune using azimuth and altitude controls (up and down).

We tested this feature many times using our 3-inch refractor, and every time the initial altitude determined by the mount was very accurate, but the mount needed rotating a few degrees in azimuth to put the target in the field of our 10mm eyepiece. Once the position is confirmed via the handset, the mount is ready to go, tracking and finding multiple objects with ease.

Go2Nova™
Do you want to run the assist alignment wizard? Press ENTER key to proceed. Press BACK key to exit.
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ENTER
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STOP 0
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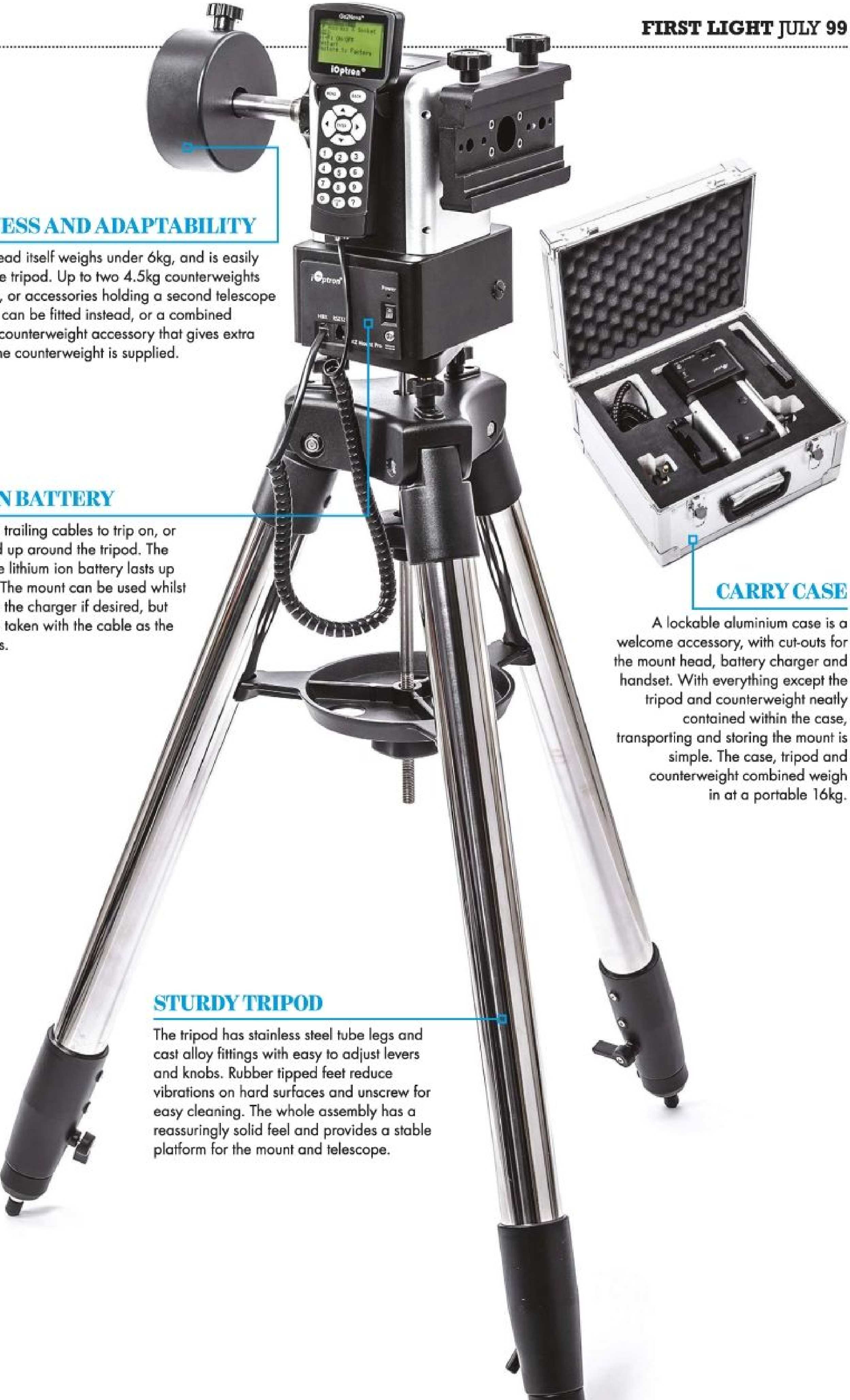


LIGHTNESS AND ADAPTABILITY

The mount head itself weighs under 6kg, and is easily lifted onto the tripod. Up to two 4.5kg counterweights can be fitted, or accessories holding a second telescope (4.5kg max) can be fitted instead, or a combined battery and counterweight accessory that gives extra capacity. One counterweight is supplied.

BUILT-IN BATTERY

There are no trailing cables to trip on, or to get wound up around the tripod. The rechargeable lithium ion battery lasts up to 10 hours. The mount can be used whilst plugged into the charger if desired, but care must be taken with the cable as the mount rotates.

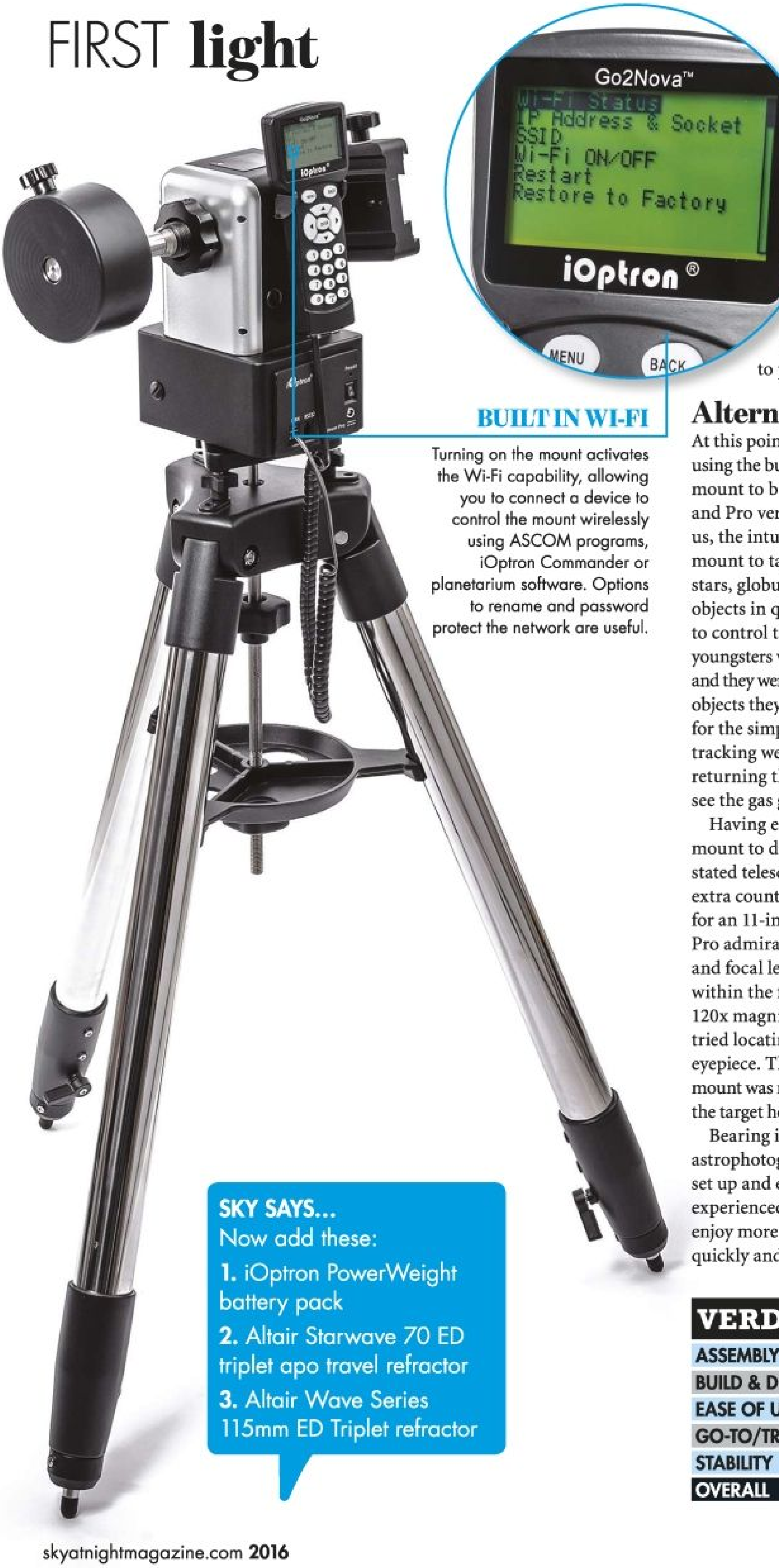
CARRY CASE

A lockable aluminium case is a welcome accessory, with cut-outs for the mount head, battery charger and handset. With everything except the tripod and counterweight neatly contained within the case, transporting and storing the mount is simple. The case, tripod and counterweight combined weigh in at a portable 16kg.

STURDY TRIPOD

The tripod has stainless steel tube legs and cast alloy fittings with easy to adjust levers and knobs. Rubber tipped feet reduce vibrations on hard surfaces and unscrew for easy cleaning. The whole assembly has a reassuringly solid feel and provides a stable platform for the mount and telescope.

FIRST light



BUILT IN WI-FI

Turning on the mount activates the Wi-Fi capability, allowing you to connect a device to control the mount wirelessly using ASCOM programs, iOptron Commander or planetarium software. Options to rename and password protect the network are useful.

SKY SAYS...
Now add these:

1. iOptron PowerWeight battery pack
2. Altair Starwave 70 ED triplet apo travel refractor
3. Altair Wave Series 115mm ED Triplet refractor

▸ within the view of our 10mm eyepiece at 50x magnification.

With a massive database of deep-sky objects to choose from, we took advantage of good sky conditions to enjoy a mini Messier marathon. The reliability of the mount at finding objects quickly, quietly and accurately was impressive, although we found the handset itself a little clunky to navigate, without shortcuts to popular objects.

Alternative controls

At this point we linked the mount to our smartphone using the built-in Wi-Fi, a simple process allowing the mount to be controlled by the Sky Safari app (Plus and Pro versions), and the sky really came alive for us, the intuitive navigation interface guiding the mount to target after target. We observed double stars, globular clusters, and some fainter Messier objects in quick succession. Using a smartphone to control the mount even appealed to some local youngsters with no previous experience of astronomy, and they were able to quickly find and view planetarium objects they found interesting, which speaks volumes for the simplicity of using this mount. To test the tracking we centred Jupiter and walked away; on returning three hours later, we were impressed to see the gas giant still held in a central position.

Having excelled so far in everything we asked the mount to do, it was time to raise the stakes. The stated telescope capacity is 15kg, so we attached an extra counterweight and swapped our light refractor for an 11-inch Schmidt-Cassegrain. The AZ Mount Pro admirably handled the large increase in weight and focal length, and managed to put each target within the field of our 23mm eyepiece, working at 120x magnification. Pushing things yet further we tried locating some double stars using our 10mm eyepiece. This was a bit more hit and miss, but the mount was never too far from the mark. Once centred, the target held fast while the mount quietly tracked it.

Bearing in mind that this mount is not for astrophotography but for visual use, it is simple to set up and easy to use. The AZ Mount Pro enables experienced astronomers and newcomers alike to enjoy more of the night sky, reliably finding targets quickly and accurately. Ⓢ

VERDICT

ASSEMBLY	★★★★☆
BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★☆
GO-TO/TRACKING ACCURACY	★★★★☆
STABILITY	★★★★☆
OVERALL	★★★★☆

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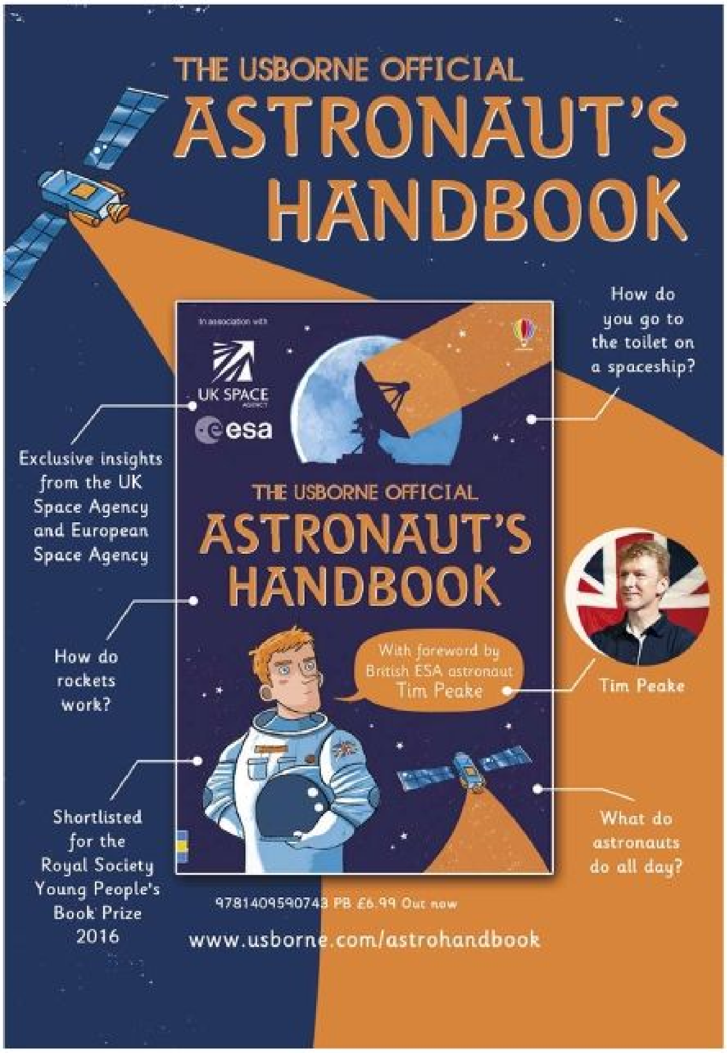

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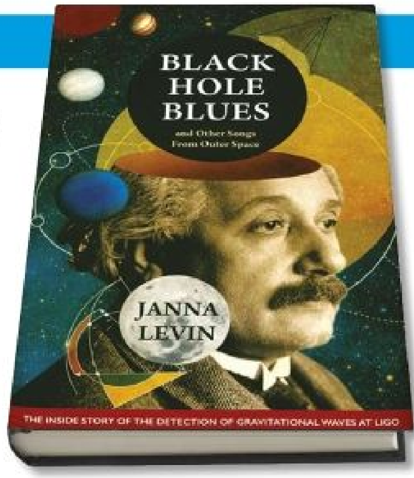
Books

New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid



Black Hole Blues

And Other Songs from Outer Space

Janna Levin
The Bodley Head
£17.99 ● HB

In September 2015, the twin Laser Interferometer Gravitational-Wave Observatory (LIGO) detectors in the US both recorded gravitational waves from the merger of two black holes after a long and arduous search.

The detection heralds the opening of a new window on the Universe: gravitational wave astronomy, essentially the study of ripples in spacetime predicted by Einstein. In this book, Levin charts the history of LIGO, which has the potential to unveil extraordinary new details about violent astronomical events.

Levin gives a nice description of the LIGO detectors, the first of which were built around 2000 and subsequently upgraded. She makes a passionate case for the promise of future gravitational wave projects to probe superdense objects like black holes and neutron stars; even ones that we have no prospect of ever detecting with conventional telescopes. LIGO and its successors will allow us to 'hear' these objects as they ring in space and time.

The jacket on this book bills it as "the full inside story of the detection of gravitational waves ... one of the most ambitious feats in scientific history," yet the book seems over-stuffed with social anecdotes. There's nothing wrong with such things when they bring something to the subject – insight into personalities, the scientific process or maybe humour. Well chosen and used sparingly, they can turn a non-fiction book into a real page-turner that's impossible to put down.

In *Black Hole Blues*, the anecdotes often seem mundane or irrelevant, as though an exercise in adding 'colour' has failed. An additional problem sees discussion of the waves' actual discovery left to an epilogue. Timing is difficult in publishing, but it might have been worth a quick edit.

LIGO Livingston, in Louisiana, (above) has a twin 3,000km away in Hanford, Washington

CALTECH/MIT/LIGO LAB

Anyone with an interest in poetic language might find the book appealing, however. For example, Levin ends with a prediction that "the wreckage of our Solar System will eventually fall into black holes, as will everything else in the cosmos, the expanding space eventually silent, and all the black holes will evaporate into oblivion near the end of time".

★★★☆☆

HAZEL MUIR *is a science writer and author of* Science in Seconds

TWO MINUTES WITH JANNA LEVIN

Why is the LIGO discovery of such importance?

This is the first time we have recorded gravitational wave sounds, so an entirely new observational dimension has opened. The two black holes that collided 1.3 billion years ago did so in darkness. No telescope could see the event, yet it was more powerful than any detected since the Big Bang. Still, the sound was incredibly quiet by the time it struck Earth and was recorded by LIGO.

What is your own work and experience in this field?

For many years my research has focused on black hole collisions. I have been particularly interested in complex, dynamical orbits. The motion of the mallets – of the black holes – determines the sounds of the ringing drum: spacetime. I'm also interested in the most rapidly spinning black holes.

Was it difficult to fit it all in 240 pages?

The book was nearly twice as long at one point. My editor said, "Why are you burying these incredible stories?" I knew what I had to do. The book broke in half so cleanly. I put aside an entire book's worth of expository material on black holes and sat down to write this much shorter story. It's like the Twain quote: "I didn't have time to write you a short letter, so I wrote a long one instead." I took the time to write a short book.

What's next for the study of gravitational waves?

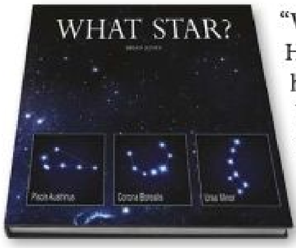
Hopefully something we have never thought of before.

JANNA LEVIN *is professor of astrophysics at Columbia University in New York*

What Star?

BOOK OF THE MONTH

Brian Jones
Regency House
£10.61 • HB



"What star is that?" How many times have astronomers been asked this simple question when sharing the beauty of the night sky with others? This book provides the answers clearly and concisely.

With so many potential stars to discuss, it would be all too easy to produce tables and lists containing all the required data, but imparting little in the way of enjoyable reading. Happily, Brian Jones avoids this trap in *What Star* with a writing style that is easy and flowing; one that pulls you into the subject matter like a magnet.

Starting with a useful explanation of why the stars visible to us change over an observing year, the book shows the constellations on view for each season, as well as those that are circumpolar. Both the northern and southern hemispheres are covered, giving the book a global appeal.

Each constellation is examined in depth with a brief mythological introduction and information about the brighter stars. The emphasis here is on star content, however, including open and globular star clusters. Where relevant, many other deep-sky objects get a mention too.

Each section is accompanied by a clearly produced sky chart to aid in locating objects, and the more obscure constellations also have a finder chart. Interesting historical references accompany the text, and many good quality colour images are included for good measure. However, the pleasure from this book is to be found in the simple charts and clear narrative.

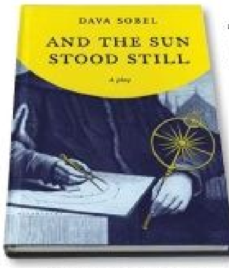
A very enjoyable read for beginners looking for a helping hand to navigate the cosmos.

★★★★★

STEVE RICHARDS *is BBC Sky at Night Magazine's Scope Doctor*

And the Sun Stood Still

Dava Sobel
Bloomsbury
£15.58 • HB



The year 1543 was the 'annus mirabilis' when Earth was relegated from the centre of the known Universe to just another planet orbiting the Sun. This major advance in our understanding of the Solar System was caused by the long-delayed publication of Copernicus's revolutionary heliocentric model, and Dava Sobel, renowned author of popular science books such as *Galileo's Daughter* and *Longitude*, has written a play dramatising this historical episode.

Copernicus was only persuaded to publish his work after meeting the younger mathematician Rheticus, but almost nothing is known about this encounter, making it ideal fodder for a dramatic reconstruction. Sobel's earlier book *A More Perfect Heaven* deals with the same subject and also includes a version of this play; now reworked and presented here as a stand-alone piece.

As one might expect for such an experienced science communicator, the amount of detail included is well judged and the reconstruction of what might have happened is interesting. Sobel suggests that Rheticus only sees the heliocentric model as a mathematical convenience, in contrast to Copernicus's declaration that it is literally true.

But the characters never come across as real people and appear simply as mouthpieces for the different arguments. In comparison, another play telling the related story of Galileo's observations, Bertolt Brecht's *Life of Galileo*, presents the growing support for the heliocentric model in a wittier and more rounded way.

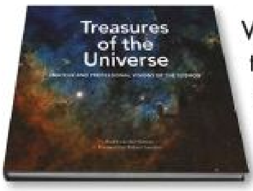
This play might be a useful educational tool, but I can see little value in buying this version without the commentary included in Sobel's earlier book.

★★★☆☆

PIPPA GOLDSCHMIDT *is a science writer and astronomer*

Treasures of the Universe

André van der Hoeven
Astro-photo
€34.95 • HB



We live in the golden age of amateur astrophotography. Thanks to sensitive digital cameras and powerful software, dedicated astronomy aficionados capture the stunning beauty of planets, star clusters, nebulae and galaxies in a way that easily surpasses the professional results of a few decades ago, as shown by the *Hotshots* section of this magazine.

Dutch astrophotographer André van der Hoeven started out in 2010 and has achieved impressive results. Not only does he take his own astro images; he also delves into the existing photo archives of telescopes such as Hubble, Spitzer and Chandra to create new composite views – they won him second place in ESA's 2012 Hidden Treasures competition.

The book's subtitle is *Amateur and Professional Visions of the Cosmos*. Indeed, *Treasures of the Universe* contains many images (and their captions) grabbed from the websites of NASA and ESA, but a substantial fraction of the 200-plus images in the beautifully designed book were either shot by the author or composed from existing data.

Unfortunately, there is almost no background on techniques; this is a collection of spectacular images with accompanying texts. But it does show the results that can be achieved by amateur astrophotographers. As the author writes: "The coming decades will reveal significant developments and we can only dream of what the future will bring us."

★★★☆☆

GOVERT SCHILLING *is an astronomy author and popular science writer*

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

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2

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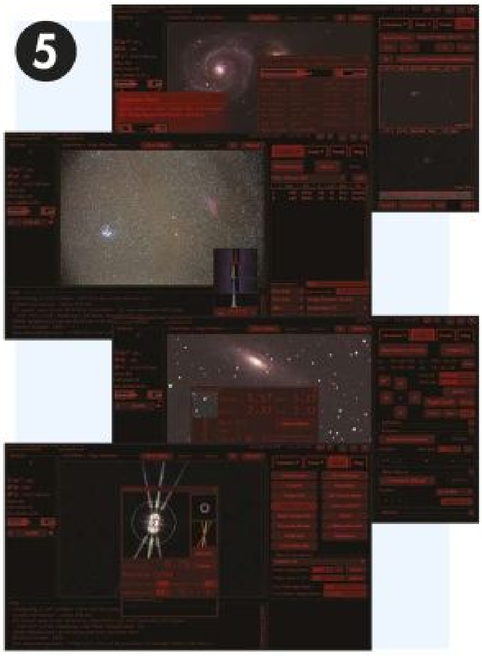

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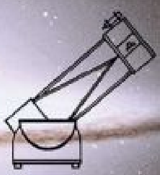

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WHAT I REALLY WANT TO KNOW IS…

How can space mining help astronomers?

Ian Crawford is looking forward to commercial space activities supporting the work of planetary scientists

INTERVIEWED BY PAUL SUTHERLAND

Astronomy and related sciences are becoming increasingly expensive to carry out. Planetary scientists like myself want to see geologists on the Moon and Mars, discovering more about these worlds. Astronomers want ever more powerful telescopes to probe the secrets of the Universe.

The next big orbiting observatory, the James Webb Space Telescope, has been so costly that it has used up much of NASA's astrophysics budget. But in the next few decades we're going to need much bigger, more powerful telescopes still to probe exoplanets around nearby stars, for example.

For this to happen, space has to start paying for itself, and I think the answer must be for the money to be siphoned off the growing space economy. Commercial companies are busy setting up to exploit asteroids or the Moon for materials, or to offer space tourism. A symbiotic relationship between this commercial space exploration and space science seems essential. Unless it happens, then we won't be able to afford the next generation of space science.

Getting access

In April I chaired a meeting of representatives of commercial companies and scientists from the US, UK and ESA at the Royal Astronomical Society to discuss how humanity can access space resources. One company plans to mine the billions of tons of water-ice to be found in the permanently shadowed craters near the lunar poles. They want to mine it, extract hydrogen and oxygen to make rocket fuel, and set up gas stations in orbit where spacecraft can fill up.

More precious materials can be found in the asteroids. Even a small asteroid can be worth many billions if not trillions of dollars thanks to the materials they contain such as silicon, aluminium, nickel, iron and platinum-group elements, as well as the water. Again, private enterprise is keen to get involved and their activities will support the work of those wanting to perform pure science.

Making use of asteroids and the Moon is not the same as plundering. It would be much more environmentally acceptable than mining Antarctica, or chopping down forests in Poland or the Amazon.

This is not true of the Moon and it is not true of millions of lumps of rock in the asteroid belt. You can't really do any damage to those things, in fact it would be preferable to obtain our resources from these objects then to exploit a planet that is occupied by a living biosphere and which can be damaged by our activities.

The infrastructure for commercial space activities, such as mining and tourist flights, will make science affordable. I think there is a parallel with the benefits that the commercial air industry gives scientists today. When I started working as an astronomer, I used to have to go observing in Australia a lot and then when I became a planetary scientist I did fieldwork in Iceland. To get to these places I got on a commercial aircraft flight.

I would never have got a research grant if I'd had to factor in the development of a whole aviation infrastructure, including an aeroplane, building an airport with air traffic control and everything, just to enable me to make these astronomical and geological observations. It would have been impossible. But because this infrastructure was already there to fly people away on holidays and business trips, it became possible.

The aviation industry has facilitated scientific activities that would not otherwise happen. And that is the kind of thing that I think could happen to help astronomers and planetary scientists in the future if the space industry takes off.

In the future, could mining facilities be built around asteroids, only to be dismantled when the space rock's minerals have been depleted?

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ABOUT IAN CRAWFORD

Ian Crawford is Professor of Planetary Science and Astrobiology at Birkbeck University of London. His interests range from lunar geology to designing futuristic starships to travel to nearby star systems.

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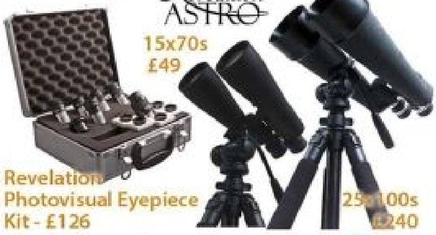

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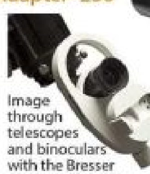

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The Southern Hemisphere in July

With Glenn Dawes

WHEN TO USE THIS CHART

1 JUL AT 00:00 UT
15 JUL AT 23:00 UT
31 JUL AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

JULY HIGHLIGHTS

Three showers are expected to peak at the end of July, when the last quarter Moon leaves the morning skies nice and dark. The Alpha Capricornids, seeming to come from the constellation of Capricorn, peak on 30th, while the Piscis Austrinids (with a radiant in Piscis Austrinus) and the Southern Delta Aquariids (coming from Aquarius) both reach maximum around the 28th. Meteors are unpredictable, with mostly a few faint streaks per hour, but fireballs do happen!

STARS AND CONSTELLATIONS

The constellation of Hercules is low in the northern evening sky. Its most prominent feature is the four stars of the Keystone asterism: mag. +2.9 Zeta (ζ) Herculis brightest and top left, then mag. +3.9 Epsilon (ε), mag. +3.2 Pi (π) and mag. +3.5 Eta (η) . If you include mag. +2.8 Beta (β) and mag. +3.1 Delta (δ) Herculis above it, it now forms the Butterfly asterism. Perhaps the constellation of Ara, the Altar, high in the south, would have made a better celestial lepidopteron. What do you think?

THE PLANETS

Jupiter is the obvious bright 'star' low in the early northwest evening sky. On the 9th it is in conjunction with the thin crescent Moon less than 2° away. Mars and Saturn are well placed, with the former due north around 20:00 EST by mid month and the latter following an hour later. Mars has drifted from mag. +1.1 Antares (Alpha (α) Scorpii) and Saturn into Libra. Mercury and Venus slowly rise out of the evening glare to be visible in the twilight for the last week of July.

DEEP-SKY OBJECTS

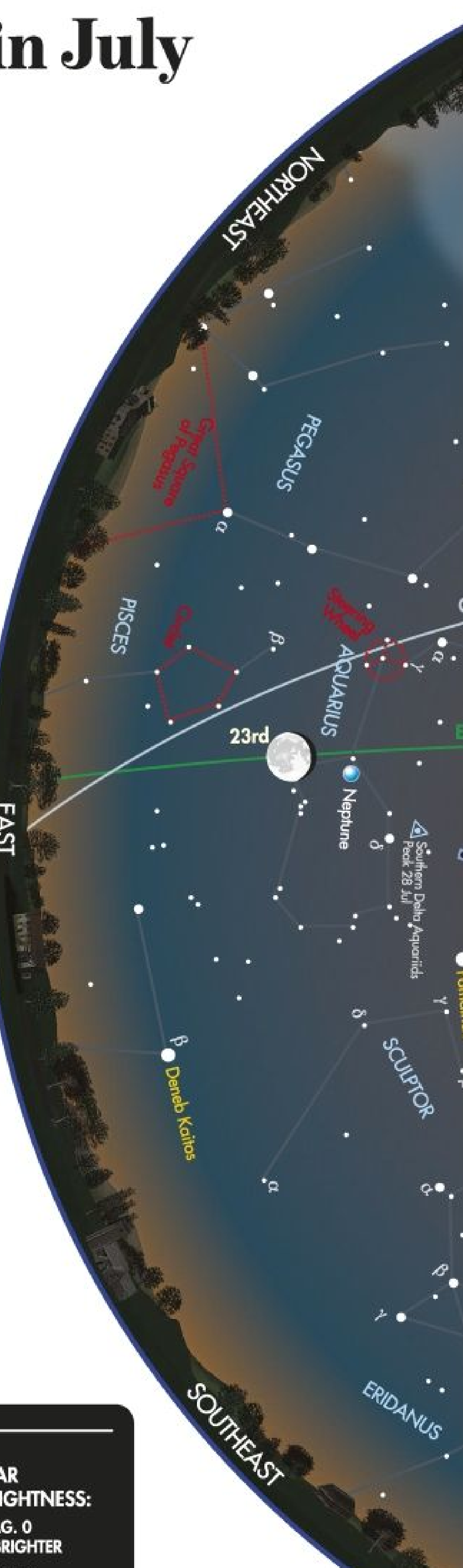
In the northern sky lies the constellation of Scutum and the open star cluster M11 (RA 18h 51.1m, dec. –6° 16'). At mag. +5.8, M11 is clearly visible in binoculars as a haze surrounding its central 8th magnitude star. The cluster is so star rich it resembles a loose globular. Its lines of stars look like birds flying in formation, hence its common name: the Wild Duck Cluster.

Following the Milky Way southwest by 12° brings you to M17, the Omega or Swan Nebula in Sagittarius (RA 18° 20.8m, dec. –16° 11'; pictured). At mag. +5.8 this bright, impressive nebula is visually similar to its images but without the colour. M17's 12 arcminute-long central bar dominates the field, while an extension comes off the western end forming the bird's curving neck.

CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- ● MAG. 0 & BRIGHTER
- ● MAG. +1
- • MAG. +2
- • MAG. +3
- · MAG. +4 & FAINTER



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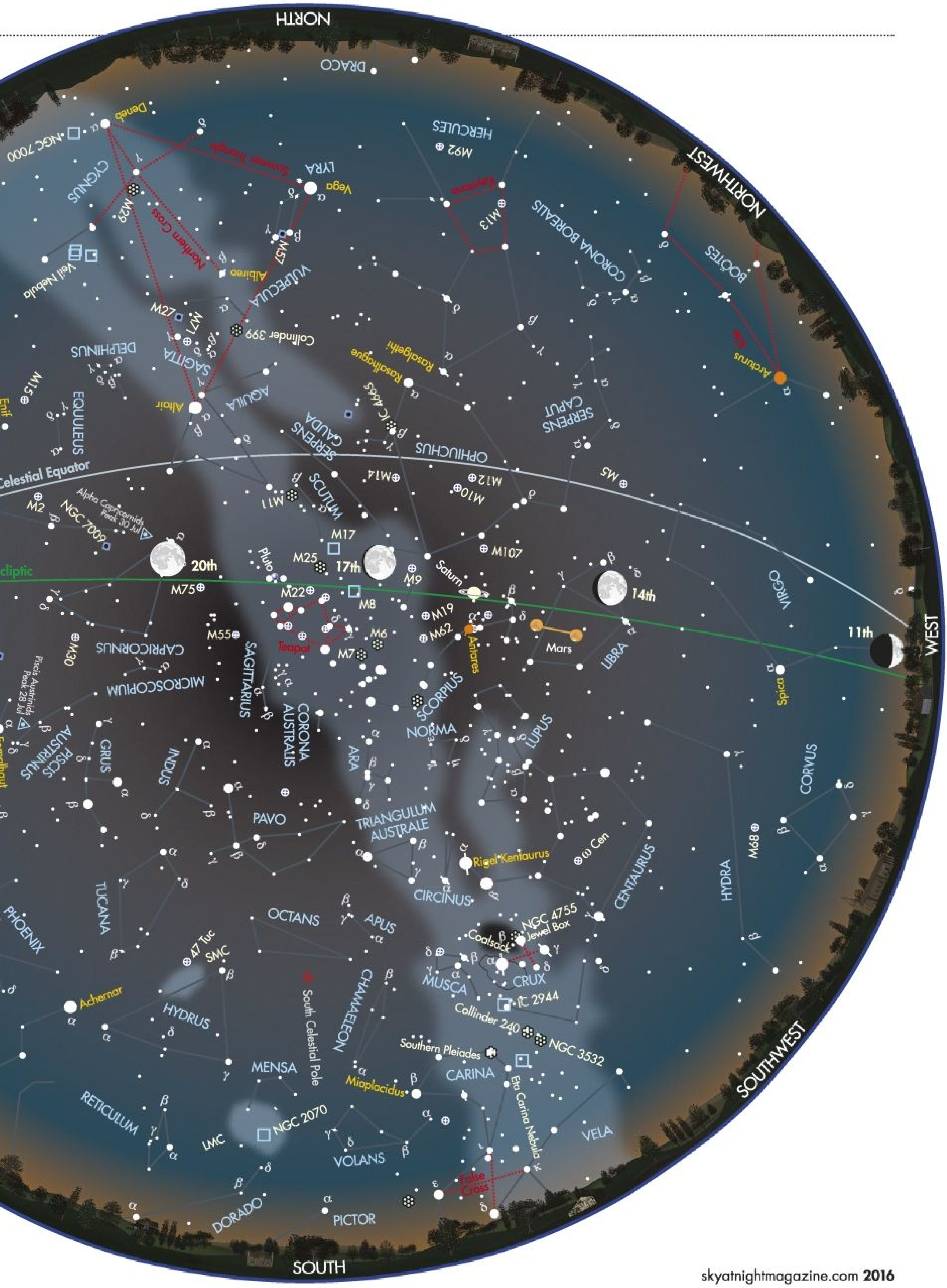
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CARINA
Eta Carina Nebula
RETICULUM
LMC
NGC 2070
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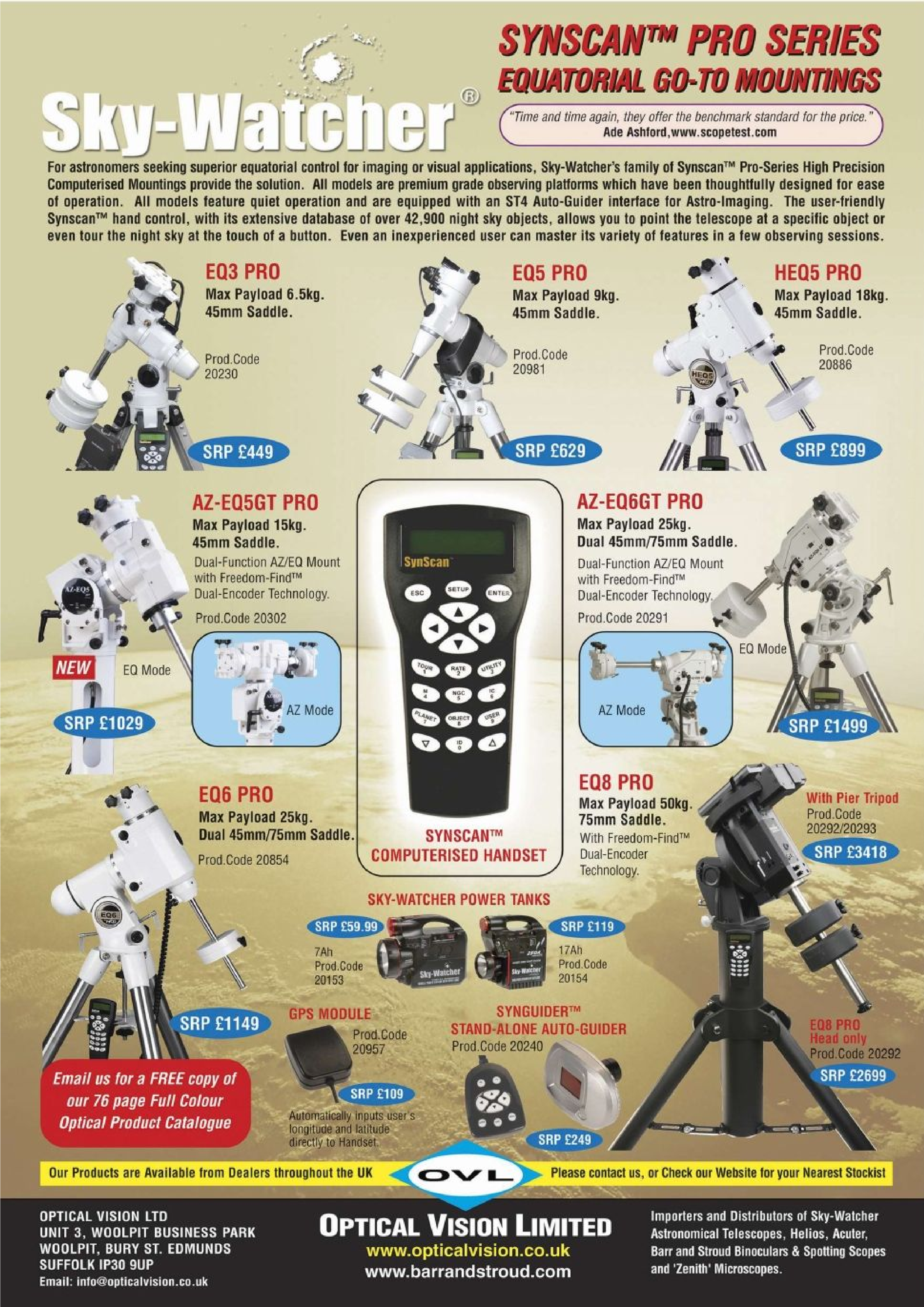
VELA
False Cross
DORADO
PICTOR



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SYNSCAN™ PRO SERIES
EQUATORIAL GO-TO MOUNTINGS

> *"Time and time again, they offer the benchmark standard for the price."*
> **Ade Ashford, www.scopetest.com**

For astronomers seeking superior equatorial control for imaging or visual applications, Sky-Watcher's family of Synscan™ Pro-Series High Precision Computerised Mountings provide the solution. All models are premium grade observing platforms which have been thoughtfully designed for ease of operation. All models feature quiet operation and are equipped with an ST4 Auto-Guider interface for Astro-Imaging. The user-friendly Synscan™ hand control, with its extensive database of over 42,900 night sky objects, allows you to point the telescope at a specific object or even tour the night sky at the touch of a button. Even an inexperienced user can master its variety of features in a few observing sessions.

EQ3 PRO
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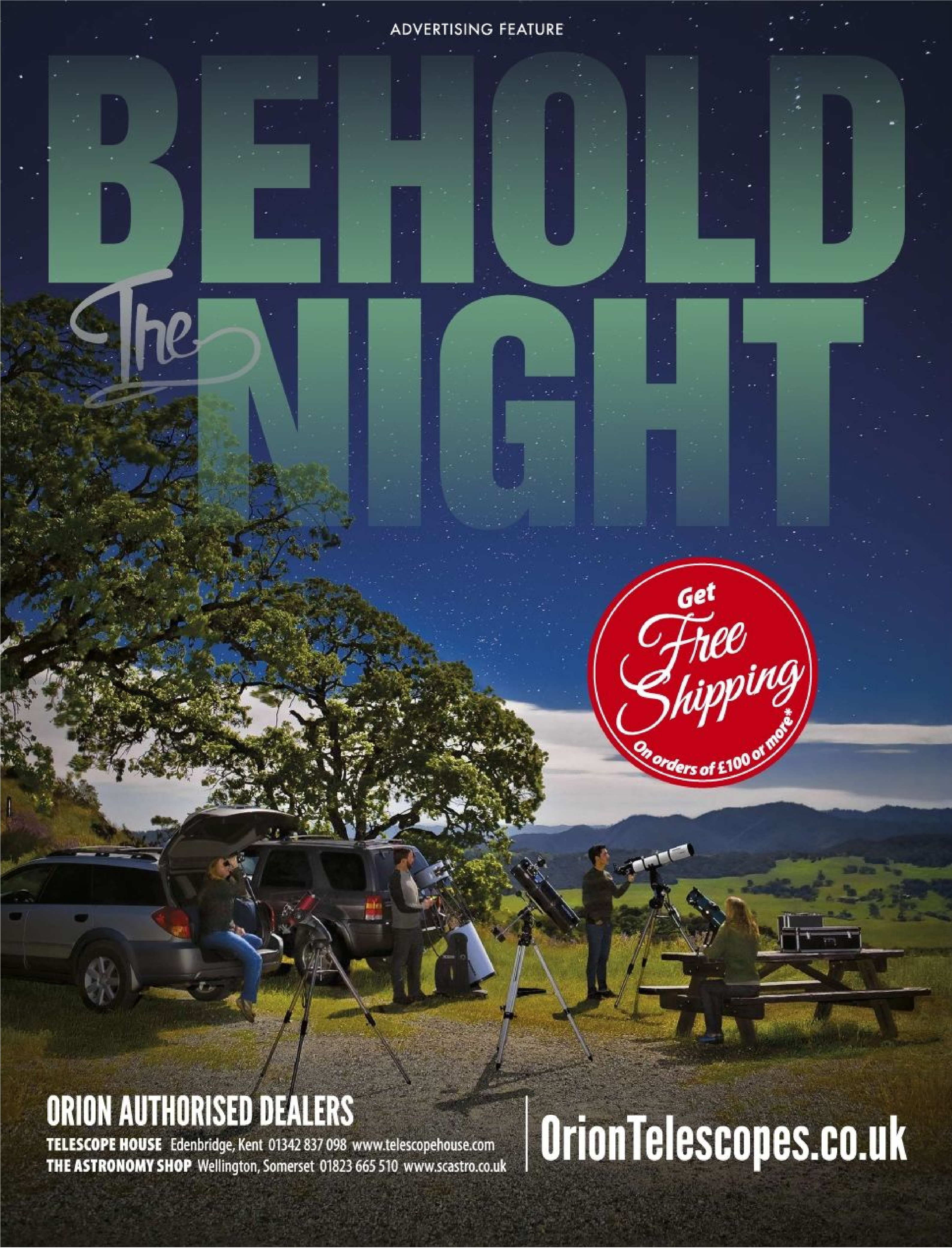

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NEW PRODUCT 2016

NEW PRODUCTS FROM ORION

*Here are just a few of our newest astronomy products. Visit **OrionTelescopes.co.uk** today to see our complete assortment, and check back often to see the newest Orion gear.*

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Orion® Ritchey-Chrétien Astrograph Telescopes

Orion 6", 8" and 10" Ritchey-Chrétien Astrographs bring advanced, affordable imaging performance to amateur astrophotographers. Each model combines the highly regarded Ritchey-Chretien optical design with excellent light-gathering capability, high-end features, and durable construction.

Orion® 6" f/9.0 Ritchey-Chrétien Astrograph
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#8267 £799.99

Orion® 10" f/8.0 Ritchey-Chrétien Astrograph
#8266 £2,299.99

Orion® StarShoot™ AutoGuider & 60mm Guide Scope Package

The reliable StarShoot AutoGuider's 1/2" format, 1.3-megapixel CMOS monochrome chip makes it a great match for the 60mm Guide Scope thanks to its small 5.2-micron x 5.2-micron pixels. Since the StarShoot AutoGuider features female T-hreads, secure threaded attachment onto the included 60mm Multi-Use Guide Scope is nice and easy.

#21404 £399.99

Orion® 60mm Multi-Use Guide Scope with Helical Focuser

With its large 60mm lens and smooth helical focuser, our newest guide scope will help you capture better quality astrophotos. What's more, this Multi-Use scope can be used as a straight-through 60mm finder by inserting an optional 1.25" eyepiece.

#13008 £187.43

Orion® StarShoot™ AutoGuider Pro & 60mm Guide Scope Package

With the included 60mm Multi-Use Guide Scope and super-sensitive StarShoot AutoGuider Pro, this efficient autoguiding solution will guide you to capturing higher-quality astrophotos.

#21405 £499.99

Orion® StarSeeker™ IV 150mm GoTo Mak-Cass Telescope

This big, 5.9" diameter GoTo Mak-Cass boasts a super-long 1800mm focal length and f/12 focal ratio to provide exceptional, high-resolution views of objects in its GoTo database. Includes a 2" visual back, 1.25" adapter, and 23mm and 10mm eyepieces which provide 78x and 180x magnification, respectively.

#13166 £827.99

Orion® FunScope™ Astro Dazzle 4.5" Reflector

The FunScope Astro Dazzle is a full-fledged f/4.4 reflector with a sophisticated, 4.5"-aperture parabolic primary mirror and 500mm focal length. Includes complete telescope with pre-assembled base, 25mm and 10mm eyepieces, EZ Finder II and an Orion MoonMap 260!

#10075 £139.99

ORION DOBSONIANS

Since 1981, Orion has led the way in offering innovative and high-quality Dobsonian telescopes – "Dobs" for short. Today, Orion offers more types and models of Dobs than could ever have been imagined by the early telescope making pioneers. Our vast selection includes a full range of ***XT Classic Dobs***, value packed ***PLUS Dobs***, computer-aided ***IntelliScope Dobs*** equipped with power saving "push-to" object location, conveniently collapsible ***XXi IntelliScope Truss Tube Dobs***, fully motorized ***XTg GoTo Dobs***, and our ***XXg series of GoTo Truss Tube Dobs***. Stay tuned to see what comes next in Orion's Dobsonian Revolution!

1981
The Original Orion Dobsonian

1993
Launch of the Deep Space Explorers

1995
Deep Space Explorers get a Face Lift

1999
Orion Introduces the SkyQuest XT Series

2003
Digital Dobs Have Arrived: SkyQuest XT Intelli-Scopes

2003
Redesigned XT Classic Dobs Take the Stage

Orion® SkyQuest™ XT8 Classic Dob
#8945 £312.44

Orion® SkyQuest™ XT8 PLUS Dob
#8974 £419.99

Orion® SkyQuest™ XT10g GoTo Dob
#10135 £1,418.10

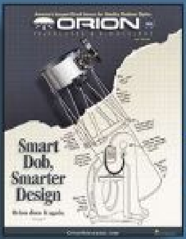
Visit ***OrionTelescopes.co.uk*** to see our full assortment of Dobsonian telescopes!

Orion® SkyQuest™ XT12i IntelliScope Dob
#10020 £1,016.89

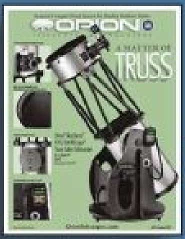
Orion® SkyQuest™ XX14i IntelliScope® Truss Dob
#10024 £1,640.15

Orion® SkyQuest™ XX16g GoTo Truss Tube Dob
#8968 £3,034.29

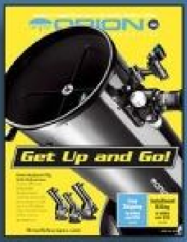
Shark Fin Cove, *Image: Steve Peters.*



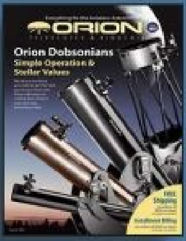
2008
Big Dobs Go Portable, XX Truss Tube Series



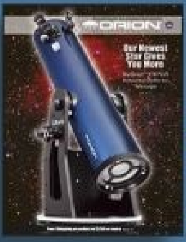
2009
XXi Truss Tube IntelliScopes Earn Rave Reviews



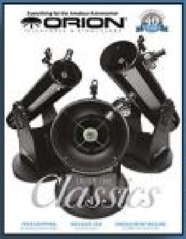
2010
The Debut of Motorized XTg GoTo Dobs



2011
Orion Leads the Way in Dobsonian Innovation



2013
Orion Introduces SkyQuest XT PLUS Dobs



2015
XT Classics Still Going Strong!

STARGAZING ADVENTURES

Orion® 150mm Mak-Cass Optical Tube

USER LEVEL Intermediate ***Back by popular demand!*** This 5.9"-aperture Mak-Cass telescope puts superior resolving power at your disposal for both observing and astrophotography. Thanks to its combination of long 1800mm focal length and substantial aperture, this compact f/12 catadioptric delivers exceptionally crisp, high-power views. The versatile 150mm Mak-Cass can be used during the day when used with optional eyepieces and a 45° correct-image diagonal (sold separately). Features 2" visual back.

#9967 £536.75

Orion® 180mm Mak-Cass Optical Tube

USER LEVEL Advanced Looking for something to satisfy your appetite for power? Try a big Mak! Our Orion 180mm Mak-Cass sets a new standard for superb high-power performance in a remarkably compact design. With 7" of aperture and that long focal length Mak aficionados love, you'll get tack-sharp, high-contrast views and clearly defined astrophotos. Features 1.25" visual back.

#9969 £1,060.85

Orion® SpaceProbe™ 130ST EQ Reflector

USER LEVEL Beginner This Short Tube (ST) version of the SpaceProbe 130 is 24" long, compared to 33" on our standard 130. The focal length of the 130mm (5.1") primary mirror is 650mm (f/5), yielding a wide field of view and brighter images. Now the sweet: the 130mm aperture diffraction-limited primary parabolic mirror is the same type used on scopes costing much more. The EQ-2 mount allows you to manually track objects as they appear to migrate across the night sky.

#9007 £199.99

Orion® StarBlast™ 4.5 EQ Reflector

USER LEVEL Beginner The StarBlast 4.5 EQ Reflector telescope's short focal length serves up a generous chunk of sky in the eyepiece, making it easy for beginners to find celestial objects. Observations of everything from the Moon to Messier objects appear sharp and rich in contrast through this petite reflector.

The included 15mm eyepiece provides 30x power magnification, while the 6mm eyepiece provides 75x magnification. The included EQ-1 mount allows you to easily track objects as they appear to move across the night sky.

#9798 £179.99

Orion® AstroView™ 90mm EQ Refractor

USER LEVEL Intermediate The AstroView 90mm refractor's objective lens is just 12.5% bigger in diameter than an 80mm lens, yet it delivers 26.5% more light to the eyepiece. Views of the moon and planets will be more highly resolved and a larger selection of brighter deep-sky objects will be visible. The EQ-2 mount lets you track targets with slow-motion control knobs. Standard accessories include 25mm (36x) and 10mm (91x) Sirius Plössl eyepieces, a 6x30 finder scope, 1.25" star diagonal, and tripod accessory tray.

#9024 £252.12

Orion® AstroView™ 120ST EQ Rich-Field Refractor

USER LEVEL Intermediate Not all refractors are designed for high-power probing of the planets. With its short focal length and generous aperture, the AstroView 120ST ("Short Tube") takes refractor usage to new depths – as in deep sky! It's designed for wide-field observation of nebulas, star clusters, and even galaxies. Its multi-coated 120mm achromatic objective lens has a focal length of just 600mm (f/5), and yields a sprawling 2.1° with the included 25mm Sirius Plössl eyepiece.

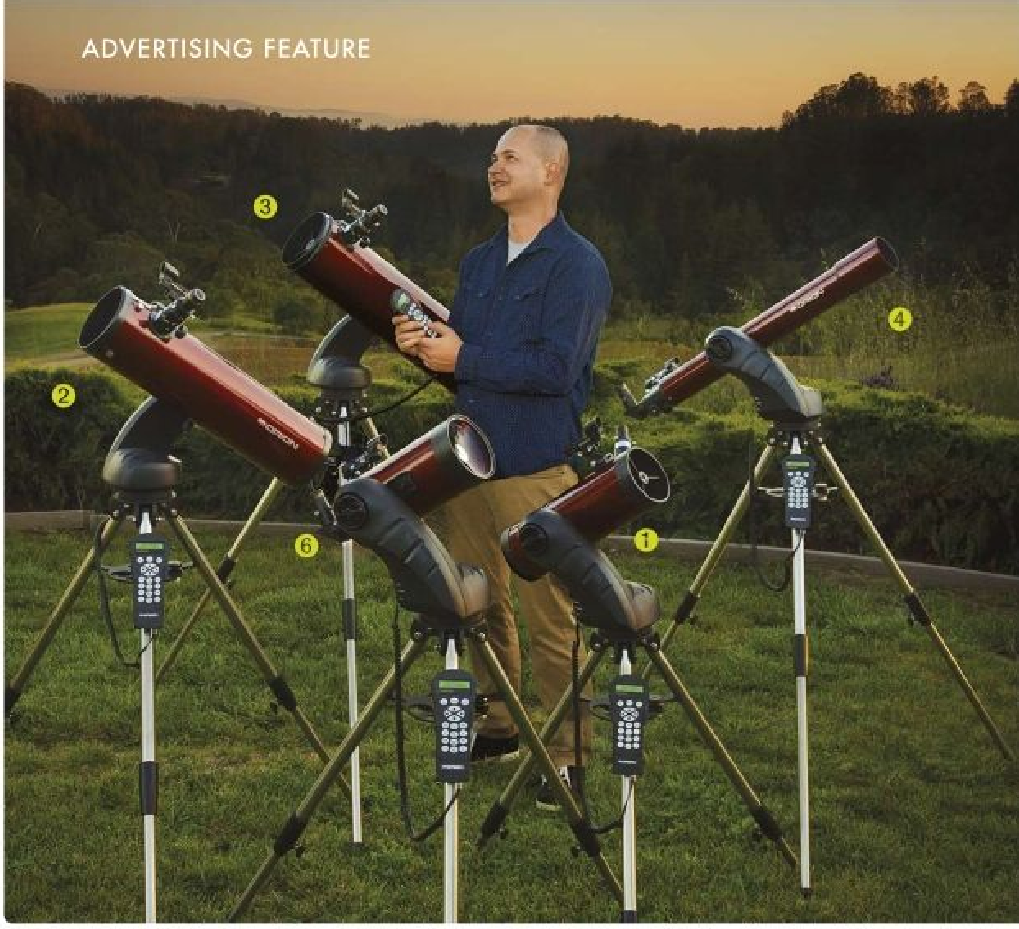
#9005 £492.04

YOUR GUIDES TO THE STARS

USER LEVEL Beginner
USER LEVEL Intermediate

Orion StarSeeker GoTo telescopes present a winning combination of motorized object-location technology and great optical performance at unbelievably low prices. Following a simple two-star alignment process, any StarSeeker IV telescope can guide you and your family to interesting sights on any clear night with their GoTo database of over 42,000 objects and handy "Tour" mode. Each StarSeeker IV features dual optical encoders on each axis of motion so you can aim the telescope either manually by hand or electronically using the included hand controller, without losing GoTo alignment.

These GoTo scopes come with two wide-field 23mm and 10mm eyepieces with a 60° apparent field, and an EZ Finder II red-dot sight for "EZ" centering of alignment stars. Requires 8 internally stored AA batteries (not included), or an included 12V DC auto-lighter plug allows use with an optional 12V DC field battery (not included).



❶ Orion® StarSeeker™ IV 114mm GoTo Reflector
#13159 £345.59

❷ Orion® StarSeeker™ IV 130mm GoTo Reflector
#13160 £383.99

❸ Orion® StarSeeker™ IV 150mm GoTo Reflector
#13161 £445.43

❹ Orion® StarSeeker™ IV 80mm GoTo Refractor
#13164 £383.99

❺ Orion® StarSeeker™ IV 102mm GoTo Mak-Cass
#13162 £460.79

❻ Orion® StarSeeker™ IV 127mm GoTo Mak-Cass
#13163 £537.59

❼ Orion® StarSeeker™ IV 150mm GoTo Mak-Cass
#13166 £827.99

Our Starseeker Family is Growing

Orion® StarSeeker™ IV 102mm GoTo Mak-Cass Telescope

This compact and easily portable GoTo Mak-Cass boasts a 4" aperture, f/12.7 optical tube to deliver sharp high-power views of the celestial objects its motorized mount can locate for you. An included 23mm eyepiece provides 57x magnification, while a more powerful 10mm ocular yields 130x views. The entire StarSeeker IV 102mm Mak-Cass weighs only 8.5kg for easy transportability, so you can enjoy GoTo object location and motorized tracking wherever the road leads you.

Orion® StarSeeker™ IV 150mm GoTo Mak-Cass Telescope

This big, 5.9" diameter GoTo Mak-Cass boasts a super-long 1800mm focal length and f/12 focal ratio to provide exceptional, high-resolution views of objects in its GoTo database. Includes a 2" visual back, 1.25" adapter, and 23mm and 10mm eyepieces which provide 78x and 180x magnification, respectively. With its combination of motorized GoTo functionality, large 150mm aperture, and high-power f/12 optics, the StarSeeker IV 150mm Mak-Cass will delight the whole family.

STEADY SUPPORT FOR SMOOTH STARGAZING

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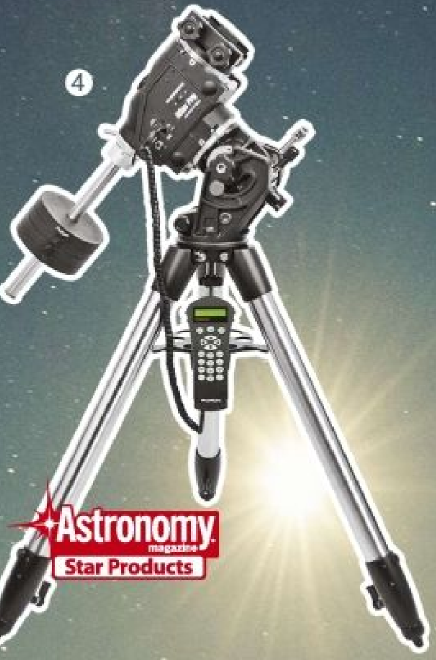
①

③

④



❶ Orion® HDX110 EQ-G GoTo Mount with Tripod Pier

Offering exceptionally low, typically +/-3 arcsecond tracking without correction (PEC) and a massive 110-lb. instrument capacity, the HDX110 EQ-G Mount offers observers and astrophotographers unprecedented accuracy for the price. The combination tripod and 5.5"-diameter pier provides solid support and three heavy-duty leveling pads are included. The Orion HDX110 EQ-G GoTo Mount requires a 12V DC, 4A power supply. A 12V DC power cable with auto-lighter plug and threaded connector is included.

#10011 £3,689.99 🎥

❷ Orion® HDX110 EQ-G GoTo Mount

For those lucky enough to have a home observatory, or who already have a permanent pier setup or preferred tripod, we offer the HDX110 EQ-G Mount without the heavy-duty tripod pier. Includes the HDX110 EQ-G equatorial mount head, counterweight shaft, GoTo hand controller, and cables. Counterweights are sold separately. *Tripod pier not included.*

#10044 £3,099.99 🎥

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❸ Orion® Atlas™ EQ-G Equatorial GoTo Mount

The popular Atlas EQ-G mount supports up to 40 lbs. on 2"-diameter stainless steel legs. You can select from over 42,000 objects and command the mount to find them. The Atlas EQ-G sports a dual-width dovetail attachment saddle that accepts both narrow and wide mounting plates, and includes an RS-232 interface cable, two 11-lb. counterweights, illuminated polar-axis scope, and 13" dovetail mounting plate. Requires external 12-volt DC power source or AC-to-DC wall adapter.

#24338 £1,199.99 🎥

❹ Orion® Atlas™ Pro AZ/EQ-G GoTo Mount

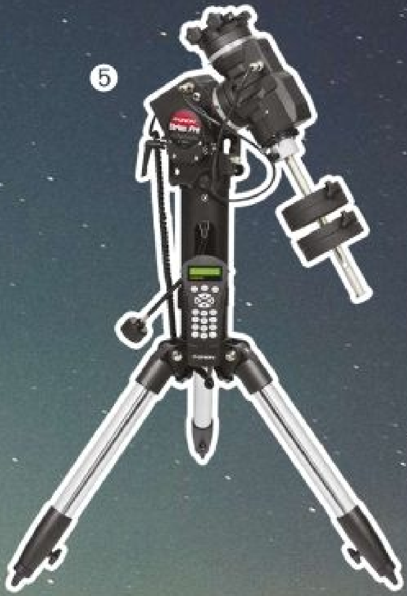
This three-in-one smart mount not only operates in equatorial GoTo mode, but also in an Altazimuth GoTo & Tracking mode while holding one or even two different telescopes.

The Atlas Pro AZ/EQ-G will carry a 44-pound payload. It's belt-driven stepper motor drive system can locate over 42,000 objects with tracking precision of 0.1436 arc-second steps. Includes 12-volt DC power cable. Requires external 12V DC power source.

#10010 £1,599.99 🎥

Did You Know…

These are just a few of the high-quality mounts and tripods available from Orion. Visit ***OrionTelescopes.co.uk*** today to see our full assortment of telescope mounts and tripods as well as specifications, helpful videos, educational articles and product support materials.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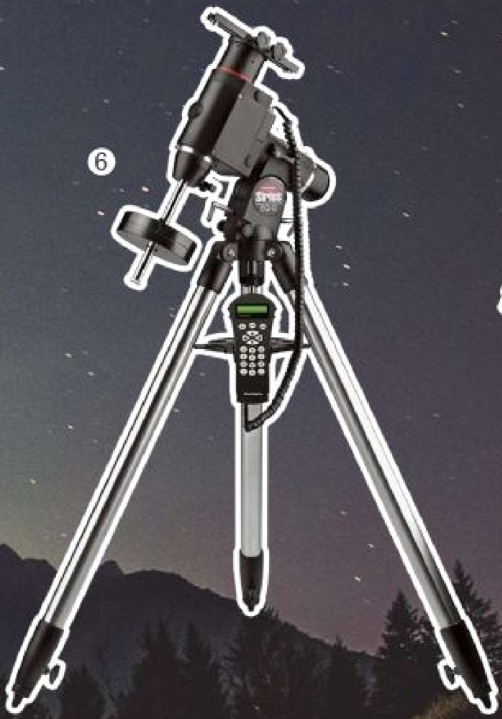
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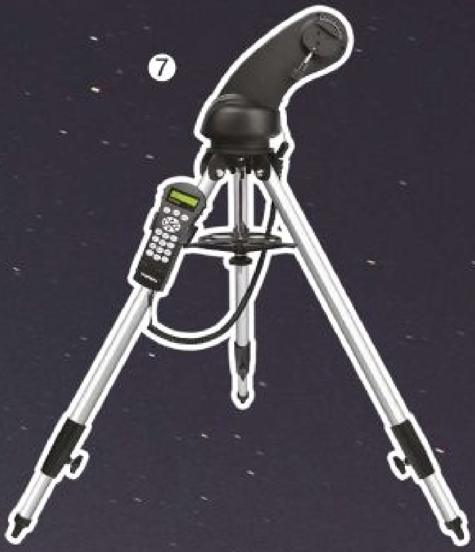
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❺ Orion® Sirius™ Pro AZ/EQ-G GoTo Telescope Mount

Rock-solid telescope support and precise tracking performance in an amazingly portable GoTo mount! The Orion Sirius Pro AZ/EQ-G Mount operates in equatorial GoTo mode holding one telescope, or in altazimuth GoTo & tracking mode with one or two telescopes attached side-by-side.

The Sirius Pro's whisper-quiet, belt assisted stepper motor drive system can locate any of over 42,000 celestial objects from its GoTo database. Closed-loop electronics feature two sets of optical encoders per axis of motion, meaning once you perform an initial alignment you can manually move the attached telescope to a new target and the mount will still know where it's pointing in the sky.

#10088 £1,257.37

❻ Orion® Sirius™ EQ-G Equatorial GoTo Mount

The Sirius EQ-G supports up to a 30 lb. load for all your visual or astrophotographic applications.

Select from over 42,000 celestial objects using the intuitive menus on the hand controller, or take a tour of the finest celestial showpieces. The internal dual-axis stepper motors slew your attached telescope precisely at up to 3.4° per second. The included tripod is remarkably sturdy, as evidenced by the 1.75"-diameter stainless steel legs. Includes an illuminated polar-axis scope, 8.3" dovetail mounting plate, and one 11-lb. counterweight. The Sirius EQ-G GoTo Mount requires a 12-volt DC power source or AC-to-DC adapter.

#24336 £979.99

❼ Orion® StarSeeker™ IV GoTo Altazimuth Mount & Tripod

This user-friendly mount boasts a state-of-the-art GoTo object location system with internal motors and a computerized database of over 42,000 celestial objects to explore. A quick-release narrow dovetail saddle makes telescope attachment nice and easy, and the slanted single-arm altazimuth design provides attached telescopes with horizon-to- zenith pointing.

After an initial two-star alignment process, dual optical encoders on each axis of motion allow you to manually reposition an attached telescope without recalibrating the GoTo system. Powered by 8 internally stored AA batteries ***(not included)***, external 12V DC field battery, or AC-to-DC wall plug adapter optional. Supports telescopes up to 13 lbs.

#13165 £322.44

PICTURE-PERFECT IMAGING GEAR

Many amateur astronomers are drawn to take pictures of the sparkling night sky through their telescope. Astrophotography is a great way for astronomy enthusiasts to share the wonders of the night sky with family and friends. What's more, astrophotos reveal features and colors that cannot be seen when looking through a telescope visually. Explore our growing line of modern and affordable astrophotography equipment on these pages and at OrionTelescopes.co.uk, and discover how easy it can be to start taking your own celestial snapshots!

Orion® SteadyPix™ Pro Universal Camera/ Smartphone Mount

This bracket securely holds yovur point-and-shoot camera or smartphone (with included smartphone holder) up to your telescope's eyepiece so you can easily capture impressive pictures. The included smartphone bracket grips phones up to 3.15" (80mm) wide and of any length.

#5306 £52.46

Orion® StarShoot™ 5 MP Solar System Color Camera

Orion StarShoot 5 MP Solar System Color Camera is built around a big, 5-megapixel (2592 x1944) one-shot color imaging sensor which has super-small 2.2 x 2.2 micron pixels perfect for capturing highly magnified exposures of the Moon and planets. Its fast capture rate of up to 50 frames per second lets you capture even the most fleeting moments of good seeing.

#52097 £170.39

Orion® StarShoot™G3 Deep Space Imaging Cameras

Available for either color or monochrome imaging, our third generation of inexpensive, entry-level cameras provide an affordable introduction to astrophotography. Their wide exposure range allows for lengthy exposures of deep space objects.

StarShoot G3 Color
#53082 £340.79
StarShoot G3 Mono
#53083 £340.79

We Can Guide You to Better Astrophotos

Orion® StarShoot™ AutoGuider Pro Mono Astrophotography Camera

This highly sensitive monochrome imaging device is primarily designed for precise autoguiding, but it also performs as a high-quality solar system camera. Boasting an astounding 74% quantum efficiency, the StarShoot AutoGuider Pro will literally "guide" you to capturing more precise astrophotos, and it features a built-in ST-4 port. The frame rate of up to 200 frames per second ensures great results. It comes with a host of useful items including a filter-threaded 1.25" nosepiece, parfocal ring, USB cable, secure RJ-11 autoguider cable, and a foam-lined tin case.

#52031 £319.99

Orion® Mini Deluxe Pro AutoGuider Package

Designed for use with imaging telescopes up to 1500mm in focal length, this complete autoguiding package includes everything you need to ensure precise tracking.

The included StarShoot AutoGuiderPro is an extremely sensitive monochrome guide camera with high 75% quantum efficiency. This affordable package also comes with our f/3.2 Deluxe Mini 50mm Guide Scope. The whole package attaches to your imaging telescope just like a finder scope.

#20011 £419.99

Orion® StarShoot™ AutoGuider Pro & 60mm Guide Scope Package

With the highly sensitive StarShoot AutoGuider Pro Mono and Orion 60mm Multi-Use Guide Scope with Helical Focuser, this complete autoguiding package will make it easy to add the accuracy of guided tracking to any astrophotography setup. The included StarShoot AutoGuider Pro's exceptional 74% quantum efficiency and sensitivity make it a perfect match for the versatile 60mm Multi-Use Guide Scope.

#21405 £499.99

TOP SHELF IMAGING SCOPES

Orion® Premium 190mm f/5.3 Maksutov-Newtonian Astrograph

USER LEVEL Advanced Our 190 "Mak-Newt" Astrograph Telescope, with flat-field, coma-suppressed optics, will deliver stunningly crisp and colorful images of deep-sky phenomena to the eyepiece. From there, an all-machined dual-speed 2" Crayford focuser with 11:1 fine focus control, will provide smooth motion and secure support for cameras and other heavy visual accessories. The 190mm Maksutov-Newtonian optics provide tremendous resolution in a fast f/5.3 design. The 7.5" aperture ensures plenty of light-gathering in order to capture superb images of even the faintest of deep-sky gems. The primary mirror and meniscus lens are secured in place by three radially positioned nylon-tip set screws, to prevent any possibility of slippage or shifting. The 37.5"-long metal tube contains five knife-edge baffles for exceptional contrast. The included focuser extension adapter allows visual astronomers to enjoy sharp, high-contrast views.

#9978 £1,599.99

Orion® 10" f/3.9 Newtonianm Astrograph Reflector

USER LEVEL Intermediate The Orion 10" f/3.9 Newtonian reflector astrograph is an amazing performer. Its mirror coatings are 94% reflective, and the 2" dual- speed crayford focuser is rock solid. Optimized for astrophotography, it boasts 10" parabolic primary optics with a fast f/3.9 focal ratio for exceptional deep-space imaging. Even especially faint galaxies and nebulas can exhibit stunning detail when photographed with a CCD imager or DSLR camera. The optical design is optimized to provide 100% illumination across an entire APS-C size imaging sensor. Extended tube length in front of the focuser and 13 internal baffles ensure optimum image contrast. An optional coma corrector is recommended to achieve flat-field imaging performance. Includes two cast aluminum tube rings, dovetail mounting bar *(not shown)*, 9x50 finder scope, 2" and 1.25" extension adapters, and a 12V DC fan for accelerated cooldown.

#8296 £577.16

Orion® ED80T Carbon Fiber Triplet Apochromatic Refractor

USER LEVEL Intermediate With an 80mm aperture triplet objective featuring FPL-53 extra-low dispersion glass, views and images captured with the Orion ED80T refractor come through true to color and exhibit tack-sharp resolution. With a focal length of 480mm (f/6.0), its fast unobstructed optics yield detail-rich visual views. The relatively small size and light weight of the refractor telescope makes it perfectly portable for escapades to dark-sky locations for either visual or photographic expeditions.

The carbon fiber refractor tube makes the ED80T CF a lightweight luxury to transport and mount. The precision machined Crayford-style telescope focuser provides dual-speed (11:1) focus adjustment perfect for dialing in delicate details. Included hard case with custom die-cut foam interior for storage and safe transport.

#9534 £762.67 🎥

Orion® Ritchey-Chrétien Astrograph Telescopes

USER LEVEL Advanced **USER LEVEL Intermediate** The compact Ritchey-Chrétien design utilizes hyperbolic primary and secondary mirrors to achieve wonderfully flat images that are virtually coma-free with pinpoint star clarity. Enhanced aluminum coatings on both the primary and secondary mirrors of Orion RC's provide 94-96% reflectivity with a protective quartz overcoat. Each RC Astrograph features a machined, dual-speed (10:1) Crayford focuser with an engraved millimeter scale on the drawtube. One 2" and two 1" focus extension rings are included with each RC.

The 6" RC optical tube features a narrow "Vixen-style" dovetail mounting bar for trouble-free setup on medium-size equatorial mounts. The 8" RC has one wide "Losmandy-Style" dovetail bar on its underside, and a narrow bar along the top of the telescope tube. The big 10" Orion RC features three built-in fans to reduce cool-down time, and two wide dovetail bars attached to the top and bottom of the tube for attachment to heavy-duty equatorial mounts.

Orion® 6" f/9.0 Ritchey-Chrétien Astrograph	Orion® 8" f/8.0 Ritchey-Chrétien Astrograph	Orion® 10" f/8.0 Ritchey-Chrétien Astrograph
#8268 £399.99 🎥	**#8267 £799.99** 🎥	**#8266 £2,299.99** 🎥

ENHANCE YOUR OBSERVATIONS WITH ORION ACCESSORIES

Our extensive assortment of affordable astronomy accessories will help you get the best performance from your telescope each and every night. From eyepieces to padded cases, Orion has everything for the amateur astronomer!

Eyepieces

Using several different focal length telescope eyepieces provides a range of magnification options. Since eyepieces can have different eye relief, lens designs and field-of-view sizes, we encourage you to explore our thorough assortment of eyepieces to find the best oculars to enrich your stargazing hobby.

Orion® Stratus™ Wide-Field 1.25"/2" Eyepieces

£120.36 each

Filters

Moon, planetary, and light pollution filters for telescope eyepieces selectively block and transmit portions of the visual spectrum to enhance features and details of celestial objects. More specialized narrow-band filters allow astrophotographers to optimize images.

Orion® 1.25" Basic Set of Four Color Filters

#5514 £42.59

Barlow Lenses

A Barlow lens boosts the magnifying power of any compatible telescope eyepiece. Popular 2x Barlow lenses double the magnifying power of a telescope eyepiece, while other more specialized Barlow lenses increase magnification by a factor of 3 or more.

Orion® Shorty™ 1.25" 2x Barlow Lens

#8711 £37.70

Solar Filters

Our safe full-aperture glass and film solar filters are designed to cover the entire front of a telescope so you can enjoy viewing the Sun and interesting phenomena like sunspots, eclipses, transits and more. *CAUTION: Never look at the Sun, even for an instant, without a properly fitted solar filter, or serious eye damage can occur.*

Orion® Full-Aperture Glass Telescope Solar Filters

£70.07 - £139.35 each

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sales@telescopehouse.com
www.telescopehouse.com

The Astronomy Shop
Wellington, Somerset
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www.scsastro.co.uk

CELEBRATING 40 YEARS

For over 40 years our commitment to quality, service and support has made Orion your one-stop source for affordable amateur astronomy gear. We're proud to continue our tradition of helping our curious customers discover the joys of stargazing with our growing assortment of telescopes, binoculars and astronomy accessories.

Diagonals

Use a diagonal in a refractor or Cassegrain telescope to bend the light path for a more comfortable viewing position. Some diagonals re-orient the view through a telescope to match your observing preferences. Diagonals are not recommended for use with Newtonian reflector telescopes.

Orion® 1.25" Dielectric Mirror Star Diagonal
#8880 £78.52

Finders

A finder scope or similar aiming device helps you accurately aim your telescope so you can enjoy astronomical views. Orion carries a variety of affordable "red-dot" reflex-sights, magnified finder scopes, specialized right-angle correct-image and illuminated-crosshair finder scopes.

Orion® 9x50 Illuminated Right-Angle CI Finder Scope
#7020 £112.50

Padded Telescope Cases

Protect, store, and transport your valued telescope and/or mount safely with a specially designed case from Orion. Our extensive assortment of rugged cases are made with padding sewn into the inner lining for extra protection.

Orion® Padded Cases for Telescopes & Mounts
£73.23 - £344.62

Accessory Cases

Keep your eyepieces, Barlows, Filters, and other astronomy gear ready for stargazing action in an Orion Accessory Case. These foam-lined cases will keep your accessories organized, clean and safe so you can enjoy them night after night.

Orion® Deluxe Medium Accessory Case
#5958 £35.12

MORE TO EXPLORE

*Visit **OrionTelescopes.co.uk** today to browse our entire assortment of affordable astronomy accessories and learn more about value-packed accessory kits, useful Scope Cloak covers, helpful star charts, guides and much much more!*

Orion® 1.25" Premium Telescope Accessory Kit
#8890 £144.83

KEEP BOTH EYES ON THE SKY

#51464

Orion® Astronomy Binoculars

Our amazingly affordable Astronomy Binoculars have been designed to provide peak viewing performance. Their large aperture means gathering plenty of light for extensive astronomical exploration. High quality BAK-4 porro prisms and anti-reflection multi-coatings on every air-to-glass surface ensure as much light as possible reaches you so views are full of detail. The 15x70 model includes a tripod L-adapter, and the 20x80 features a built-in heavy-duty tripod adapter for easy attachment to a field tripod or binocular mount. Tripod use is highly recommended for long viewing sessions with these big astronomy binoculars.

15x70 Astronomy Binocular ☾
#51463 £68.06 🎥

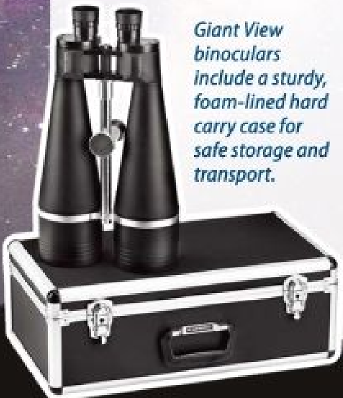
20x80 Astronomy Binocular ☾
#51464 £101.35 🎥

Orion® Giant View™ 25x100 Binoculars

It's the same night sky, all right. But with our jumbo Giant View binoculars, you'll see it like never before. Their large-aperture, fully multi-coated optics provide exceptional light gathering capability for stargazing.

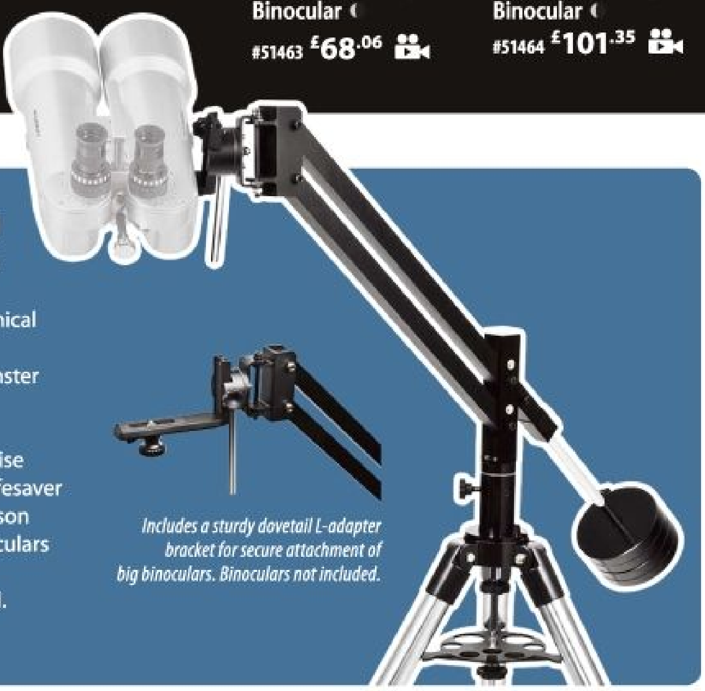
The BAK-4 prisms and internal baffling ensure sharp images and pleasing contrast. The eyepieces focus individually, which affords a higher degree of focusing precision than center-focus mechanisms.

25x100 Giant View ☾
#9326 £295.63 🎥



Giant View binoculars include a sturdy, foam-lined hard carry case for safe storage and transport.

☾ – *These binoculars are great for stargazing.*



Includes a sturdy dovetail L-adapter bracket for secure attachment of big binoculars. Binoculars not included.

Orion® Monster Parallelogram Binocular Mount & Tripod

Our Monster Parallelogram is specifically designed for use with gigantic astronomy binoculars, and will provide hour after hour of comfortable viewing and silky-smooth motion control. It can support giant astronomical binoculars weighing up to 15 pounds with up to 100mm-diameter objective lenses. Since balance is vital for such large binoculars, the Monster Parallelogram Mount boasts six degrees of motion to make balancing easy and accurate. Two 11-pound counterweights are included.

This crowd-pleasing mount's parallelogram design can be used to raise and lower attached binoculars without disrupting the aim, which is a lifesaver when stargazing with family and friends of varying height, so each person can enjoy the view of the same object. You can position attached binoculars up to 6' and as low as 2'6". Includes anodized L-bracket for binocular attachment, convenient handle for easy slewing, and assembled tripod.

#5752 £425.99

Orion® 10x42 Waterproof Monocular

Orion® 10x42 Waterproof Monocular with a big, 42mm objective lens and 10-power magnification, this compact and portable monocular will let you enjoy magnified views of distant wildlife, birds, scenery, sporting events, and even the Moon without packing a lot of bulky equipment. What's more, its rugged, rubber-armored body and waterproof construction make the Orion 10x42 Monocular ideal for use in virtually any weather conditions.

#8431 £50.84

Orion® Beginning Stargazer's Toolkit

With the affordable Orion Beginning Stargazer's Toolkit, you'll never be "lost in space!" It contains four vital reference items and tools designed to help new astronomers find their way around the heavens. Toolkit includes: Orion Star Target Planisphere, Discover the Stars guidebook, Orion MoonMap 260 and Orion RedBeam Mini LED keychain flashlight.

#20034 £32.73

SHARP VIEWS SERVED DAILY

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❶ Orion® 10x50 Wide-Angle UltraView™ Binoculars

The UltraView's feature a much wider field of view (6.5°) than standard 10x binoculars. Excels for high-power astronomy, long-distance nature observation, and hunting. This binocular's cast alloy metal construction holds up admirably under extensive field use. Black rubber armoring protects the binocular against bumps and scratches, and finger grooves provide a sure grip.

#9351 £143.59 🎥 ◑

❷ Orion® ShoreView™ Pro Waterproof Roof Prism Binoculars

With substantial, 42mm objective lenses, these binoculars collect a good amount of light in order to produce clear, detailed daytime views. Lightweight and pleasantly portable, ShoreView Pros are easy to pack along as you explore the outdoors, and since they're waterproof, you won't have to worry if you get caught in the rain!

Orion 8x42 ShoreView Pro WP
#51647 £54.90 🎥

Orion 10x42 ShoreView Pro WP
#8449 £59.12 🎥

❸ Orion® Resolux™ Waterproof Astronomical Binoculars

Professional quality Resolux binoculars are fully waterproof and nitrogen purged to prevent internal lens fogging. The extra-large BAK-4 prisms and advanced multi-coatings on all optical surfaces really drink in the light.

The Resolux's all-metal housing is armored with thick rubber to ensure a secure, comfortable grip. Each binocular comes with lens caps, heavy-duty tripod adapter, and neck strap.

7x50 Resolux ◑
#9543 £211.16

10.5x70 Resolux ◑
#9545 £312.52

15x70 Resolux ◑
#9546 £312.52

❹ Orion® GrandView™ 16-48x65mm Waterproof Zoom Spotting Scope

With fully multi-coated optics packed into a durable waterproof housing, the Orion GrandView spotter will amaze you with crisp views. It provides zoom magnification from 16x all the way up to 48x and features a big, 65mm objective lens. It even sports a nifty rail mount for an Orion EZ Finder Deluxe II reflex sight to aid in aiming. *(Finder sold separately.)*

#52205 £94.94 🎥

❺ Orion® StarBlast™ 62mm Compact Travel Refractor

Get great views wherever you go with the portable Orion StarBlast 62mm Refractor! During the day, the included 45° correct-image diagonal makes it a perfect high-quality spotting scope. At night, the advanced 4-element, high resolution, fully multicoated f/8.4 optical design lets you enjoy great views of starry skies.

#10149 £340.79

❻ Orion® Apex™ 90mm Mak-Cass

A terrific grab-and-go or travel spotter. Its 1250mm focal length (f/13.9) yields 50x magnifying power with the included 25mm Plössl eyepiece. The finder scope is a 6x20 correct-image. Weighs 3.7 lbs. Tube length, 10".

#9820 £211.08 🎥

ADVERTISING FEATURE

GREAT GEAR UNDER £250

For over forty years, Orion has proudly offered a vast assortment of high-quality affordable astronomy gear to our valued customers. Whether you're looking for a complete telescope setup, or an addition to your collection of useful stargazing accessories, we have everything you need at great prices.

FREE SHIPPING on orders of £100 or more* **OR** **£7.95 FLAT-RATE SHIPPING** no minimum order*

Orion® SteadyPix™ Pro Universal Camera/Smartphone Mount, 1.25"
#5306 £52.46

Orion® 1.25" Telescope Accessory Kit
#8889 £88.40

Orion® 26m 32mm 38mm Set of Q70™ Eyepieces
#24708 £219.61

Orion® StarBlast™ 70mm AZ Travel Refractor
#10028 £93.71

Orion® High-Power 1.25" 3x 4-Element Barlow Lens
#8707 £102.23

Orion® 9x50 Illuminated Right-Angle CI Finder Scope
#7020 £112.50

Orion® Ultrablock™ NarrowBand Filter
#5654 £81.84

Orion® StarMax™ 90mm TableTop Mak-Cass Telescope
#10022 £172.21

Orion® SpaceProbe™ 130 EQ Reflector Telescope
#9851 £215.03

We're here to help. Call us 00-800 8989 0123, or Live Chat with our representatives (1400-2400 GMT)

Retail prices shown are current as of 01/06/16 from Orion. Product prices include VAT.
*Prices are subject to change without notice. Please check **OrionTelescopes.co.uk** for the most current pricing. Dealer pricing and/or promotions may vary.*

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